EXPLORING THE EXPERIENCES AND PERCEPTIONS OF PROJECT MANAGERS REGARDING TECHNOLOGY TRANSFER PROCESSES

by

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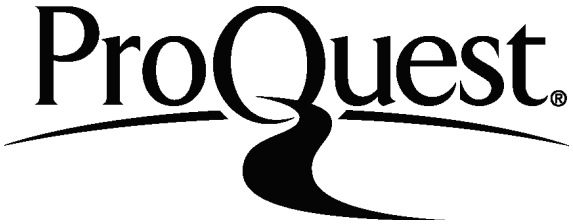

Abstract

This qualitative case study explored the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations. Technology transfer is a complicated project process that requires highly skilled personnel who understand the technology transfer practice. Activities that cause technology transfer projects to fail are lack of funding, failure to follow license and patent agreements, and poor project management practices. To meet the objectives of the study, a multiple-case study was used to describe the experiences and perceptions of project managers regarding the competencies necessary to support the process of technology transfer in four nonprofit research organizations in Missouri. The research leveraged semi-structured one-on-one interviews, biographical information, and observations. The conclusion is that the practice of technology transfer requires a broad understanding of fundamental science, intellectual property law, and business fundamentals, which are underpinned by project management practices. The experiences and perceptions shaped a competency framework and a competency model that focuses on the knowledge, performance, organizational, technology transfer, and personal competencies necessary to be a successful project manager in the technology transfer process. Although the results of the study provided a framework and model for technology manager competencies, the results are specific to small nonprofit research organizations in Missouri. Future research may focus on other similarly sized or larger nonprofit research organization within Missouri or other locations within the United States.

Dedication

I dedicate this research to project managers, scientists, lawyers, and business people who bring new technology and processes into our lives in order to improve our world. Their efforts and knowledge are captured in part through this dissertation with the expectation that this research adds value to the project management process of technology transfer.

I also dedicate this work to my loving wife, Kelly; my father and mother, Mr. Pat and Mrs. Jane Howley; my family; and my friends for standing beside me and supporting me throughout my doctoral academic journey. I know this journey took a toll on our family time. I look forward to sharing my knowledge with you as we reunite again.

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I would like to acknowledge my wife, Kelly, who is my biggest champion. She took on many of the family support activities while we served in the Army and continued to give of herself while I pursued my education goals. Lastly, I would like to thank my family and friends for providing encouragement and support throughout my life and my doctoral studies.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

Technology transfer is a complicated project process that requires highly skilled personnel who understand the technology transfer practice (Rogers, Takegami, & Yin, 2001; Speser, 2006). The practice of technology transfer requires a broad understanding of project management and business marketing (Speser, 2006). Rozenes, Vitner and Spraggett (2006) noted that lack of planning and monitoring are major causes of project failure. Cicmil and Hodges (2006) found that 31% of projects fail to meet their objectives, and that 53% either do not meet the project schedule, or exceed the project budget. Factors that cause technology transfer projects to fail include (a) lack of funding, (b) failure to follow license and patent agreements, and (c) poor project management practices (Agarwal, 2006; Bremer, 2006; Craane, 2006; Hauth, 2006). Exploring the competencies of successful project managers who have focused on the technology transfer process can help researchers to identify the skills, knowledge, and characteristics needed to effectively transfer select technology projects to commercialization.

Project management is defined as the "application of knowledge, skills, tools, and techniques to project activities to meet the project requirement" (Project Management Institute, 2013, p. 5), a structured process designed to meet project objectives. Project management processes can be applied to multiple industries, including the management of technology (Kerzner, 2009). The transfer of technology is a complicated process,

influenced by the interactions between factors such as intellectual property, markets, and funding (Speser, 2006). Drucker (1999), as well as Kerzner (2009), showed that managers contend with multiple complex challenges in daily business management and that project management is an effective solution for corporate management. Through a survey of the experiences and perceptions of technology transfer project managers, this research explored the necessary competencies of technology transfer project managers working in nonprofit research organizations.

Technology transfer is the process of moving innovative technology from a laboratory to a commercial organization (Fuller & Hahman, 2010; White & Bruton, 2011). The technology transfer process involves multiple factors including intellectual property (IP) and licensing. Market orientation is also a fundamental consideration in the transfer process (Speser, 2006). A common practice in large technology corporations and nonprofit research universities is the spin-off of a nonprofit organization created to identify new technologies and assist in commercialization (Rogers et al., 2001). Technology transfer professionals focus on market orientation, and fall into one of four groups consisting of "university and nonprofit technology transfer offices, government lab technology transfer offices, corporate licensing offices, and consulting groups" (Speser, 2006, p. xxii).

Project managers in the nonprofit technology transfer offices are the focus of this dissertation study. The researcher chose this population because of the specific technology transfer activities conducted by project managers in these offices. Understanding market orientation and other aspects of technology transfer are important factors in successfully managing technology and placing it in a position of advantage

(Porter, 1985; Speser, 2006; White & Bruton, 2011). Speser (2006) noted the importance of project manager competencies in managing the technology transfer process.

Background of the Study

A commonly accepted technology transfer process includes three phases, as shown in Figure 1: (a) the transitioning plan, (b) the market penetration plan, and (c) the funding plan (Speser, 2006). The transitioning phase focuses on moving the technology out of the laboratory and into production; the market penetration phase focuses on entering and expanding the market; finally, the funding phase focuses on the total cost of completing both earlier phases (Speser, 2006).

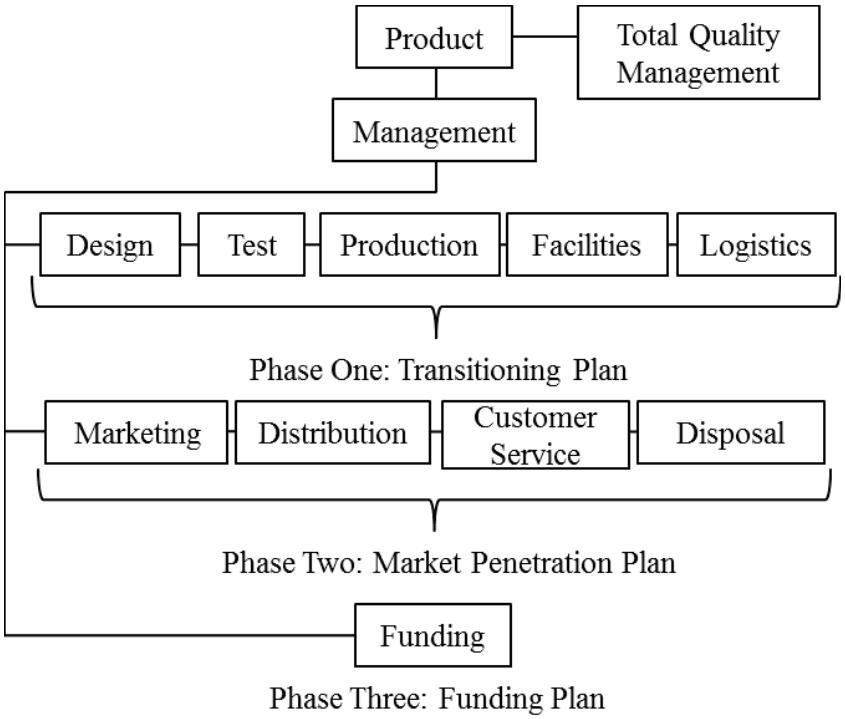

Figure 1. The technology transfer process. The template is derived from the Willoughby template, which consists of generally accepted technology transfer steps and a marketing aspect expanded by foresight (Speser, 2006). The transfer process has three phases consisting of transition, market penetration, and funding (Speser, 2006).

In the current study, the researcher focused on the competencies of the project managers who practice technology transfer in all three phases (Guay, 2006; Speser, 2006). Understanding and practicing key activities in the technology transfer process can improve the success of moving new technologies to commercialization (Kidwell, 2014; Rogers et al. 2001; Speser, 2006).

Competencies are an important aspect of shaping successful projects (Project Management Institute, 2013). Competencies consist of the skills, knowledge, and characteristics that enable success in a job (Ruyle & Orr, 2011; Sanghi, 2007). Winterton (2008) reiterated these elements, and added attitudes, behaviors, and abilities as well. As an important part of their growth, project managers focus on developing the competencies needed to meet specific project objectives (Project Management Institute, 2007). Rogers et al. (2001) showed that an understanding of the complex process of technology transfer is important in successfully managing transfer activities. Further research is needed in surveying the competencies of project managers, also known as Principal Investigators (PIs) or Technology Transfer Professionals (TTPs), engaged in the technology transfer process (Boehm & Hogan, 2014; Guay, 2006; Kidwell, 2014; Weeks, 2006). An understanding of their competencies can help to frame the deliberate practices needed for project managers to expertly perform technology tasks (Ericsson, 2006; Rogers et al. 2001; Speser, 2006; Weeks, 2006).

The theoretical framework of the current study was based on Ericsson's general theory of expertise, which focuses on developing expertise in a specific domain—such as project management and technology transfer—that requires personal discipline (Ericsson,

2006). Ericsson's theory and model of expert performance differed from earlier works that suggested "time and/or practice alone [can] not produce the highest levels of human performance" (Amirault & Branson, 2006, p. 83).

Successful management of the technology transfer process requires competence in planning and conducting activities that link innovative products or processes to commercial organizations. Rogers et al. (2001) noted that the process demands skilled personnel to plan and manage the transfer activities. Identifying key competencies and developing the project manager role in a nonprofit organization can help in the successful transfer of laboratory technology to commercialization (Ericsson, 2006; Rogers et al., 2001; Guay, 2006; Weeks, 2006).

Statement of the Problem

Within the technology transfer community of practice, there is a lack of clear understanding of which competencies are needed for technology transfer project managers working to ensure project success in nonprofit research institutions (Rogers et al., 2001). Many project managers develop competencies in nonprofit research institutions through self-guided and lecture learning methods that support specific technology transfer skills. These development programs center on the use of (a) traditional project management processes, (b) templates, and (c) technical skills, and may be augmented with technology transfer information (Association of University Technology Managers, 2016b; Project Management Institute, 2007). Development programs reinforce the use of traditional management methods as well as organizational processes and templates (Project Management Institute, 2007). Lamancusa, Zayas, Soyster, Morell, and Jorgensen (2008) showed that, although the lecture method provides

information to students, it is "quite ineffective for stimulating higher-order thinking" (p. 7). Lamancusa et al. (2008) stated that "interactive hands-on experiences; and experiential, team-based learning involving student, faculty and industrial participation [enrich] the educational process and [provide] tangible benefits to all" (p. 7). Fink, Ambrose, and Wheeler (2005), as well as Weeks (2006), reinforced this perspective, showing that team-based learning is a valuable learning strategy. Rogers et al. (2001) noted that there is a need to understand the competencies of technology transfer project managers in nonprofit research organizations as well as the learning approaches that lead to development of such competencies.

The goal of a technology transfer project is to select and move noteworthy innovations from the laboratory to commercial enterprises that will provide a high return on investment. The practice of technology transfer thus requires a broad understanding of project management and business marketing (Speser, 2006). Rozenes et al. (2006) reported that lack of planning and monitoring are major causes of project failure. Agarwal (2006), Bremer (2006), Craane (2006), and Hauth (2006), found that technology transfer projects fail due to lack of funding, disregard of license and patent agreements, and poor project management practices. Exploring the competencies of successful project managers who focus on the technology transfer process can help to identify the skills, knowledge, and characteristics needed to effectively transfer select technology projects to commercialization.

Purpose of the Study

The purpose of this multiple-case study is to describe, through the experiences and perceptions of project managers in four nonprofit research organizations in Missouri,

those competencies that are needed to support the process of technology transfer. The research uses semi-structured one-on-one interviews, biographical information, and direct observations (Baxter & Jack, 2008; Creswell, 2013; Patton, 2002; Yin, 2014). Technology transfer competencies reflect the knowledge and skills necessary to manage the movement of technology from the laboratory to a commercial organization (Creswell, 2013; Fuller & Hahman, 2010; Speser, 2006; White & Bruton, 2011; Yin, 2014). The researcher's effort will help fill the gap in knowledge that currently exists in the body of knowledge of the research and development (R&D) technology transfer project manager community (Rogers et al., 2001). Maryman's (2011) research effort regarding the impact of project knowledge areas on information technology manufacturing, as well as Rhodes's (2014) research on selection and orientation of members in nonprofit organizations, will be extended with this study. This research will also lay the foundation to support post-graduation research in technology transfer best practices, specifically in nonprofit research organizations.

Rationale

A qualitative multiple-case study design is well suited to answer the research question by exploring the *how* and the *why* of a select group of individuals who work in the research and development industry as expert project managers (Baxter & Jack, 2008; Patton, 2002; Yin, 2014). Exploring their experiences, and their perceptions of the skills, knowledge, and ability required in technology transfer activities, provides a better understanding of the professional competencies needed to successfully move technology innovation from research to commercialization (Boehm & Hogan, 2014; Rogers et al.

2001; Sanghi, 2007). Identifying necessary skills, knowledge, and abilities will help to improve the practice of technology transfer activities in nonprofit research organizations.

Research Question

What are the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations?

Significance of the Study

The significance of this case study to organization and management is the identification of key technology transfer competencies of successful R&D technology transfer project managers (Rogers et al., 2001). Successful R&D technology transfer projects normally include (a) invention disclosures, (b) patent applications, (c) income-yielding technology licenses, (d) start-up companies spurred by the technology, and/or (e) licensing royalties earned per year (Rogers et al., 2001). Understanding project manager competencies is an important factor in acquiring, developing, and completing projects (Crawford, 2006; Project Management Institute, 2013). Project managers who can perform multiple technology transfer activities are important to the successful business activities of nonprofit research institutions (Rogers et al., 2001).

The National Science Foundation (2015) and The White House (2015), as well as Rogers et al. (2001), have noted the significance of effective strategic investment in science and technology as a means of sustaining national leadership in R&D. Loch and Payne (2011) highlight the importance of strategic planning in organizations. In this work, the researcher will explore, through a multiple-case study, the technology transfer competencies of successful project managers. This exploration could help to improve

competency models for R&D technology transfer project managers and support strategic organizational science and technology goals.

Definition of Terms

The definition of key terms in the research helps in applying Ericsson's general theory of expertise to project management and to the technology transfer practices that frame the foundation for this study. The terms cross three communities of practice, those of (a) project management, (b) technology transfer, and (c) talent development. The key terms for this research are as follows:

- *Project management*: the "application of knowledge, skills, tools, and techniques to project activities to meet the project requirement" (Project Management Institute, 2013, p. 5).
- *Technology transfer professional*: a person who manages the process of moving technology innovation from a laboratory to a commercial organization (Alliance of Technology Transfer Professionals, 2016b; Fuller & Hahman, 2010; White & Bruton, 2011). The activities of the technology transfer professional may include development of (a) disclosure statements, (b) license agreements, (c) patent applications, and (d) other forms of intellectual property actions.
- *Nonprofit research organization*: an organization with a focus on supporting and managing the technology transfer process and commercialization goals as well as the growth of new high-technology companies (Missouri Technology Corporation, 2016; Speser, 2006). For the purposes of this study, the

organization is located within the context of university and nonprofit technology transfer offices or institutions (Speser, 2006).

- *Intellectual property (IP)*: a term used to describe protected ideas. Protection may come in the form of trademarks, copyrights, trade secrets, and patents (Gordon, Cookfair, LoTempio, & Lillis, 2013).
- *Competencies*: a group of personal characteristics that affect one's job performance and which can be associated with accepted community standards and practices (Association for Talent Development, 2016; Project Management Institute, 2007; Sanghi, 2007).

Assumptions and Limitations

The assumptions and limitations outlined in this research are based on Ericsson's general theory of expertise and the qualitative research method of case study. The qualitative research method of case study is an approach that centers on an in-depth examination of a complex phenomenon in its natural context (Patton, 2002; Yin, 2014). Crowe et al. (2011), Flyvbjerg (2011), and Yin (2014) have noted that case study is a research approach with an intense focus on investigating a phenomenon bound by its real-life context. A case study fosters an understanding of the real-world case through exploring, explaining, or describing the phenomenon (Yin, 2014). This research uses a multiple-case study approach and this section highlights assumptions and limitations considered as part of the research effort in project management technology transfer competencies. The assumptions and limitations help frame the context of this research.

Assumptions

The assumptions that support this research are (a) that the participants in the case study will have developed their level of expertise through deliberate practice of technology transfer activities, (b) that project management competencies will be complementary to competencies needed by technology transfer professionals, (c) that the technology transfer organizations will generate competencies similar to one another in technology transfer practices, (d) that the interview participants will be able to accurately articulate competencies used in developing their technology transfer expertise, and (e) that the participants will be willing to provide personal historical documentation.

Limitations

One limitation of this case study is that generalizations of the identified competencies cannot be extended to other nonprofit research organizations outside of the surveyed sample. Another limitation is that the size of the sample is not representative of a larger general population (Yin, 2014). Among the potential biases associated with a case study focused on identifying business competencies that support technology transfer are the researcher's familiarity with (a) R&D projects and (b) research project managers (Bednall, 2006). Lastly, the research may highlight bias in the sample based on the number of participants who have had formal project management training (Bednall, 2006; Pannucci & Wilkins, 2010).

Theoretical/Conceptual Framework

The theoretical, or conceptual, framework for this research comprises four focus areas: (a) the expert performance model, (b) expert decision-making, (c) development of technology and marketing penetration efficacy, and (d) expert performance of technology transfer project managers (Maxwell, 2005; Moxley, Ericsson, Charness, & Krampe, 2012; Rogers et al., 2001; Speser, 2006). The model starts with the theoretical underpinning of expert performance described by Ericsson and Charness (1994). The model then presents two areas (Maxwell, 2005; Moxley et al., 2012; Speser, 2006): (a) expert management decision-making and competencies of project managers (Maxwell, 2005; Moxley et al., 2012; Speser, 2006), and (b) the transition and market penetration efficacy of the project managers (Maxwell, 2005; Moxley et al., 2012; Speser, 2006). The two areas are then joined together to describe the expert performance of project managers conducting technology transfer practices, as shown in Figure 2 (Ericsson & Charness, 1994; Rogers et al., 2001; Speser, 2006).

This research draws from Ericsson's general theory of expertise and technology transfer lessons learned, and is underpinned by project management competencies. The theoretical framework that shapes this study posits that expert practice in technology transfer activities improves the performance of project managers. The framework also shapes the successful transfer of technology to commercialization, as highlighted in Figure 2 (Boehm & Hogan, 2014; Ericsson, 2006; Kidwell, 2014; Moxley et al., 2012; Project Management Institute, 2007; Rogers, et al., 2001; Speser, 2006; Weeks, 2006; White & Bruton, 2011).

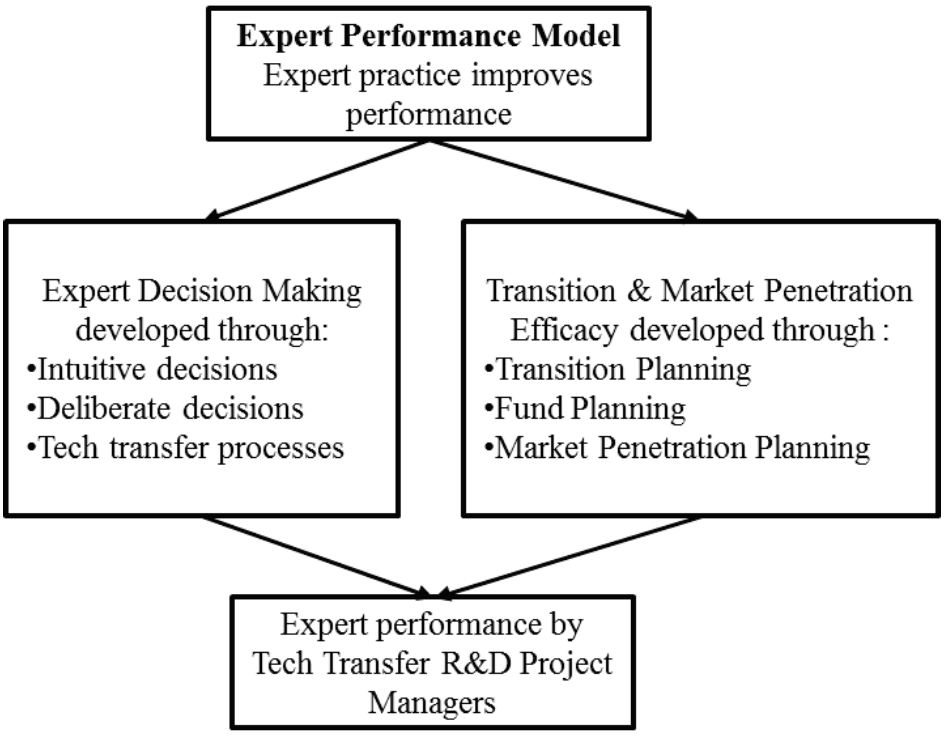

Figure 2. The conceptual theoretical framework. The framework is derived from the general theory of expertise highlighted by Moxley et al. (2012), blended with technology transfer lessons noted by Rogers et al. (2001) and Speser (2006), and leveraging a qualitative diagram outlined by Maxwell (2005).

This research will advance the scientific knowledge base by adding information to a specific project management area within the R&D arena, that of technology transfer. According to Boehm and Hogan (2014), there is a need for further research in management competencies in the R&D community, and as noted by Rogers et al. (2001), an understanding of the technology transfer processes can help to transfer innovations more effectively. This study extends prior research, noted earlier by Maryman (2011) and Rhodes (2014), and fills a gap in existing literature focused on the technology transfer skills, knowledge, and abilities of research and development project managers. The multiple-case study undertaken in this research explores these qualities in project

managers conducting technology transfer activities, specifically in nonprofit research organizations.

Organization of the Remainder of the Study

The purpose of this multiple-case study is to describe the experiences and perceptions of project managers in four nonprofit research organizations in Missouri regarding competencies needed to support the process of technology transfer. Chapter 2 of this study will present a literature review that supports this study of project managers' perspectives and experiences within nonprofit technology transfer organizations. Chapter 3 will focus on the multiple-case-study methodology used in this research, and Chapter 4 will highlight the results of the study by focusing on the themes that arose from the interviews and observations. Chapter 5 will provide (a) an analysis of the data, (b) a discussion of the results, and (c) a description of future research efforts in the field of technology transfer project management.

CHAPTER 2. LITERATURE REVIEW

Introduction

This chapter focuses on literature that supports this study of the experiences, perceptions, and competencies of technology transfer project managers working in nonprofit research organizations. This review (a) summarizes the elements of the conceptual theoretical framework, (b) provides an overview of technology transfer practices, (c) describes nonprofit research organizations, (d) highlights aspects of talent development, (e) presents competency models, and (f) concludes with a summary and analysis of case study methodology. This literature review draws from academic journals, published texts, and pragmatic resources to provide a foundation for exploring the experiences and perceptions of successful project managers in nonprofit research organizations in Missouri regarding competencies essential to the technology transfer process.

Reviewing literature provides a framework for research. Seminal works provide necessary background for literature reviews, while more recent works provide information on current views within a community of interest (Creswell, 2013; Pettigrew, Woodman, & Cameron, 2001). As noted by Pettigrew, Woodman, and Cameron (2001), reviewing recent works provides knowledge from a collective network of literature framed to support research. The literature review for this research draws on competencies found in four fields—(a) project management, (b) technology transfer, (c)

talent development, and (d) engineer development—to guide the exploration of the perceptions of project managers focused on technology transfer processes in nonprofit research organizations. The next section in this chapter focuses on (a) Ericsson's general theory of expertise, (b) expert decision making, (c) self-efficacy development, and (d) expert performance, which collectively provide the conceptual framework for this research.

Ericsson's General Theory of Expertise

Ericsson's general theory of expertise centers on developing expertise in performance. In his general overview, Ericsson (2008) provided an overview of expert performance and noted that the key construct related to actively engaging in deliberate practice focused on improving specific tasks (Ericsson, 2008). The theory used to frame Ericsson's summary is a general theory of expertise. The philosophic approach is objectivist, as noted by Ericsson, in focusing on causal relationships of superior performance and deliberate practice tasks. Ericsson highlighted the results of his review by summarizing that extensive experience does not naturally equate to superior performance. Superior, or expert, performance derives from integrating complex systems that focus on execution, planning, and performance analysis through deliberate practice of the necessary skills (Ericsson, 2008). Expertise that is developed in specific jobs centered on improving performance came into focus in the mid-twentieth century with researchers such as Robert B. Miller in the early 1960s, who studied relationships between experts in military occupations (Amirault & Branson, 2006). As cited in Amirault and Branson (2006), the development of relationships between task performance and expertise were further explored through the efforts of Fitts and Posner

in the late 1960s as well as Chi and Glaser in early 1982. Ericsson and Charness (1994) expanded earlier research on expert development with the addition of research focused on understanding the specific elements of expert performance (Ericsson & Charness, 1994). The four focus areas that comprise the theoretical conceptual framework for this research are further explored in the following sections.

Expert Decision Making

For decades, expert decision-making has been a topic of research in order to better understand how decisions can be improved. The interest in improved performance and achievement was examined in the early work of de Groot in 1946 and in that of Chase and Simon in 1973, research that focused on the decision-making of chess players and the outcomes of specific moves made during the game (Ericsson & Charness, 1994).

The seminal work by Ericsson and Charness (1994) provides a framework for understanding expert performance and highlights the relationship of experiences to successful learning. Their work draws on previous works by de Groot in describing how subjects select their chess moves and in comparing the moves of novice chess players to chess masters (Ericsson & Charness, 1994). The authors relate the acquisition of these skills to phases of development in expert performance, which leverage qualitative differences in decision making from novice involvement through full practices on a full-time basis, thereby leading to expert decisions by blending experience, deliberate practice, and continued learning to improve performance (Ericsson & Charness, 1994). The information summarized by Ericsson and Charness could lead to improvements in management decisions in business organizations.

The research presented by Moxley et al. (2012) also examines the deliberate decision-making of expert chess players. Their research question focused on accuracy of movement decision over time, based upon game simulation similar to de Groot's earlier work (Ericsson & Charness, 1994; Moxley et al., 2012). The theory drew from expert learning theory (Moxley et al., 2012). The philosophic approach was objectivist, in that Moxley et al. assessed the value of decisions made with respect to the quality of the moves conducted by the participants. The research design was quantitative, in that researchers numerically assessed the quality of the chess movement decisions in the game with respect to a computer chess program (Moxley et al., 2012). The population consisted of 71 experienced and less-experienced chess players (Moxley et al., 2012). The setting was structured as a tournament environment, with researchers observing the moves of the chess players (Moxley et al., 2012). The strength of this research is that the sample size was larger than that of previous studies and was consistent with prior research (Moxley et al., 2012). The results of the research indicated that deliberating decisions provided higher-quality moves to both expert and less-skilled chess players in their move decisions (Moxley et al., 2012). This research highlights a link to how adult learners generate understanding in an unfamiliar context, by assimilating new information with prior knowledge to understand the current situation (Moxley et al., 2012). The ability to make good decisions is important in project management and in the technology transfer process (Kerzner, 2009; Speser, 2006).

Self-Efficacy Development

The development of self-efficacy, the belief that one can improve one's performance and develop abilities to accomplish activities (Bandura, 1977; Smith, 2009), is a significant component in professional development. Hutchison-Green, Follman, and Bodner (2008) explored the self-efficacy beliefs of first-year engineering students to identify experiences that shape engineering efficacy beliefs. Self-efficacy theory framed the foundation for their research (Hutchison-Green, Follman, & Bodner, 2008). Hutchison-Green et al. sought to identify a relationship between engineer education experiences and the level of engineer efficacy beliefs. The results of their research showed that first-year engineering students focus more on comparing their engineering performance with their peers in (a) mastery of course materials, (b) student work groups, and (c) their grades (Hutchison-Green et al., 2008). The use of performance comparison by the students shows that vicarious experiences help students with limited subject-matter experience improve by learning and comparing themselves with their peers (Hutchison-Green et al., 2008).

Expert Performance

Ericsson's overview of expert performance noted that the key construct in expert performance is related to actively engaging in deliberate practice focused on improving specific tasks (Ericsson, 2008). The theory used to frame Ericsson's (2008) summary is a general theory of expertise. The philosophic approach is objectivist, as noted by Ericsson (2008), in focusing on causal relationships between superior performance and deliberate practice tasks. Ericsson (2008) highlights that superior performance does not naturally

flow from extensive experience. Superior, or expert, performance is derived from integrating complex systems that focus on execution, planning, and performance analysis through deliberate practice of the necessary skills (Ericsson, 2008). The deliberate application of processes and practices underpins the goals and objectives of professional communities such as those associated with (a) project management, (b) technology transfer, (c) talent development, and (d) civil engineering (American Society of Civil Engineers, 2008; Association for Talent Development, 2016; Association of University Technology Managers, 2016a; Project Management Institute, 2013). Expert performance is gained through deliberately practicing the skills needed to perform one's specific job, such as a project manager conducting technology transfer activities.

Technology Transfer

Technology transfer practices focus on the transfer of innovation from the laboratory to a commercial organization, underpinned by intellectual property (IP) protections such as disclosures, patents, and licenses (Bremer, 2006; Gordon, Cookfair, LoTempio, & Lillis, 2013). As defined earlier, technology transfer is the process of moving innovation from the laboratory to a commercial organization (Alliance of Technology Transfer Professionals, 2016b; Association of University Technology Managers, 2016a; Fuller & Hahman, 2010; White & Bruton, 2011). Groups found in the technology transfer community of practice are "university and nonprofit technology transfer offices, government lab technology transfer offices, corporate licensing offices, and consulting groups" (Speser, 2006, p. xxii). The Association of University Technology Managers (AUTM) is a professional organization that supports the technology transfer community of practice.

Technology transfer practices provide a process by which innovation is commercialized. This section outlines key aspects that help technology transfer project managers in this process. It summarizes important technology transfer legislation that has provided the foundation for modern technology transfer activities, and it describes fundamental elements that shape the technology transfer process: an understanding of (a) science, (b) intellectual property law, (c) business, and (d) venture capital (Guay, 2006; Vincent & Mason, 2006; Weeks, 2006). While technology transfer involves multiple considerations such as IP and licensing, market orientation is fundamental to the transfer process (Speser, 2006). The following sections provide an overview of information that is essential in the practice of technology transfer

Technology Transfer Legislation

The U.S. Constitution provides the initial foundation for technology transfer. As Bremer (2006) found, a key component of the technology transfer process—the protection of ideas or intellectual property—is framed within the U.S. Constitution. During World War II, universities contributed to the advancement of technology by disseminating knowledge that was used in industry and thereby helped to increase economic growth (Bremer, 2006). A key issue that emerged in the early 1960s was the result of an absence of a consistent government policy; the government at that time retained the title to all government-funded research and inventions (Bremer, 2006). A landmark law in technology transfer came in 1980 with the enactment of the Bayh-Dole Act (Public Law 96-517). The Bayh-Dole Act (a) enabled a more consistent federal patent policy, allowing universities to conduct research and coordinate with industry using inventions that were developed with federal funds, and (b) conferred the right to

retain the title of these inventions (Bremer, 2006). The government, however, retained the right to use such inventions worldwide for its own purposes (Bremer, 2006). The Bayh-Dole Act was amended in 1984 with Public Law 98-6205, which clarified the roles between the Secretary of Commerce and the Comptroller General, and again in 1987 with Public Law 98-620, which further refined the rights and roles of all parties involved in the transfer of technology (Bremer, 2006). The key aspect of the Bayh-Dole Act was the creation of a pathway for universities, government, and industry to establish collaborative technology efforts, which framed the foundation for modern technology transfer offices (Bremer, 2006).

Science Fundamentals

A good understanding of science provides a helpful foundation for technology transfer project managers. Lovejoy (2006) asserted that understanding science fundamentals and staying current in the sciences that lead to product innovation are important aspects of professional development in the technology transfer community of practice. Among the science fields found in technology transfer communities are medicine and life sciences, agriculture, and engineering (Rasor & Heller, 2006). A background in science helps project managers in the technology transfer process understand the appropriate application of the technology (Rasor & Heller, 2006). An ability to apply science appropriately, as well as an understanding of intellectual property law, business fundamentals, and venture capital, is an important factor in technology transfer project management.

Intellectual Property Law

Rasor and Heller (2006) noted that the ability to apply law and legal principles is important in framing the terms and special contractual conditions that support intellectual property concerns. Intellectual property protections may come in the form of trademarks, copyrights, trade secrets, and patents (Gordon et al., 2013). Being familiar with various aspects of intellectual property law protections helps project managers to oversee the commercialization of innovation.

Business Fundamentals

A grasp of business fundamentals further reinforces the foundation for successful technology transfer. MacWright (2006) observed that the success of new technology ventures relies on business expertise in addition to technical, legal, and financial considerations. MacWright also noted that business expertise is difficult to find and, in addition to funding, is important to have. The ability to apply good business practices is valuable to faculty who wish to become entrepreneurs and find business partners (MacWright, 2006). Similarly, marketing—a business fundamental—is an important aspect of the technology transfer process (MacWright, 2006). One of the technology transfer tools that spans business, science, and law is a collaborative research and development agreement (CRADA), which formalizes a research agreement and effort between an academic institution or commercial organization and a government agency (Reichman, Ano, & Ferguson, 2006). Appropriate application of the business tools available to researchers and entrepreneurs is a valuable aspect of technology transfer practices.

Venture Capital

Venture capital is a key component in technology transfer. As noted earlier, Speser (2006) highlighted the importance of funding as one of the three phases of technology transfer. Funding supports both the transition and market penetration phases of technology transfer (Speser, 2006). Venture capital firms are financial intermediaries that provide equity funding to *portfolio companies*, generally small, high-risk businesses with potentially high payoff (Metrick & Yasuda, 2011). Attracting venture capital is an essential part of technology transfer and of entrepreneurial start-ups and spin-offs (Crowell, 2006; Vincent & Mason, 2006). Leveraging venture capital practices in the funding of innovation is an important element in technology transfer project management.

Nonprofit Research Organizations

Nonprofit research organizations are tailored to fill the technology transfer needs of their supported organizations. The missions of nonprofit research organizations or technology transfer offices will vary based on their specific objectives; however, some common objectives are (a) technology transfer for public benefit, (b) economic development, and (c) facilitating startup company creation (Rasor & Heller, 2006). Nonprofit research organizations or technology transfer offices are funded either directly or through a combination of (a) government agencies, (b) grants, (c) contributions, (d) royalty revenues, and (e) general funds from the supporting organization or university (Rasor & Heller, 2006). The nonprofit research organization or technology transfer office may be in an independent location or may be a department of a research university (Rasor & Heller, 2006). The composition of the nonprofit research organization or

technology transfer office is normally tailored to capitalize on the research focus of the university or supported organization (Rasor & Heller, 2006). For example, if the university is focused on engineering and agriculture research, then the project managers and technology transfer professionals should have a background in engineering and agriculture (Rasor & Heller, 2006). The nonprofit research organization or technology transfer office normally provides the functions of (a) licensing, (b) legal support, (c) business development, (d) patent support, (e) accounting, (f) marketing, (g) research faculty, and (h) student outreach (Rasor & Heller, 2006). Individual staff may support each function, or multiple functions may reside with two or three people (Rasor & Heller, 2006). The distribution of functions within the organization depends on the size of the organization (Rasor & Heller, 2006). The organizations range in size from small, with a staff of three to eight people, to large, with approximately 50 people (Rasor & Heller, 2006; Stanford University, 2016). Regardless of size, a majority of the activities in the technology transfer offices focus on "receiving disclosures, determining whether to file, working with outside counsel on prosecution matters, finding licenses, negotiating licenses, and monitoring license compliance" (Wheaton, 2006, p. 5). The ability to apply knowledge of structure, function, and activities within the nonprofit research organization or technology transfer office helps to provide the foundation necessary to explore the experiences and perceptions of successful project managers in such organizations regarding necessary competencies in the technology transfer process.

Talent Development

Talent development increases the ability of individuals and teams to successfully achieve project objectives and meet project goals and is a fundamental activity in

professional development (Association for Talent Development, 2016; Project Management Institute, 2007). This section highlights (a) project manager competencies within the project management body of knowledge, (b) select learning methods focused on learning and performance considerations, and (c) competencies within the technology transfer body of knowledge. The review also includes competencies outlined in the civil engineering body of knowledge as an additional community reference point for potential competencies for project managers engaged in technology transfer activities in nonprofit research institutes. The civil engineering body of knowledge was selected as a reference point based upon the formal developmental process, structure, and professional requirements used in the civil engineering community of practice (American Society of Civil Engineers, 2008).

Project Team Development

Project team development shapes the outcomes and effectiveness of projects in project management and is one of the key activities found in the Project Management Executing Process Group (Project Management Institute, 2013). The activity, Develop[ing] Project Team, is "the process of improving competencies, team member interaction, and overall team environment to enhance project performance" (Project Management Institute, 2013, p. 254). Project team development improves teamwork, competencies, and overall project performance (Project Management Institute, 2013). Tools that aid in team development and learning may include team-building activities, training, and development of interpersonal skills (Project Management Institute, 2013). As noted by the Project Management Institute (2013), the benefit of project team development activities is improved project performance.

Learning-organization environments enable project teams to develop and improve. Senge (1990) outlined five disciplines of a learning organization: (a) personal mastery, (b) mental modeling, (c) team learning, (d) shared vision, and (e) systems thinking. Bui and Baruch (2010) built on Senge's (1990) work by providing a qualitative elaboration of the five disciplines, which can be applied to both business and research. The concepts presented by Bui and Baruch can be incorporated into a nonprofit research organization as waypoints to gauge the ability of the organization to learn. As noted by Bui and Baruch, a learning organization can improve its competitive advantage. The nonprofit research organization, as a learning organization, can improve its management process and be more effective in supporting the science and technology research projects that meet the needs of the organization.

Experiential Learning

Experiential learning is a process of learning from life's experiences. Kolb's (1984) seminal work on experiential learning provides a model that focuses on experience as part of the learning process in constantly developing knowledge. According to Kolb, the experiential learning theory presents a model with four focus areas: (a) concrete experience, (b) reflective observation, (c) abstract conceptualization, and (d) active experimentation. Kolb takes an objectivist philosophical assumption as he relates his findings on development of a learning theory and developed model that applies to the subject population. Kolb's work provides a perspective in the development of individual and team through experiential learning.

Interactive Engagement

Interactive engagement (IE) learning is a method of improving knowledge levels in students. Hake's (1998) research explored the effectiveness of IE methods, as compared to traditional instructional methods, in a foundational mechanics class for physics. The objectivist philosophical assumption that guided Hake was that IE improves learning. The investigation method leveraged three types of quantitative physics diagnostic survey tests (Hake, 1998). The sample size was more than 6,000 students in approximately 60 introductory physics courses in multiple high schools, colleges, and universities in the United States (Hake, 1998). One limitation of the study was the research population, which consisted of students studying basic physics in United States high schools, colleges, and universities. Another limitation was that the effectiveness was measured through the three types of quantitative physics diagnostic survey tests (Hake, 1998). One implication of the study, as suggested by Hake, is that an active teaching style can provide an effective alternative for physics teachers in the United States. An additional implication is that the interactive engagement method provides an approach to improving the basic physics knowledge of students in high schools, colleges, and universities in the United States (Hake, 1998). The main conclusion of the research was a strong positive correlation supporting the idea that IE enhances problem-solving abilities (Hake, 1998). Interactive engagement learning enables project teams to use creative problem-solving methods in developing solutions to complex challenges. The process of technology transfer is a complicated activity that requires the involvement of knowledgeable staff who are able to solve complex problems.

Professional Organizations

Professional organizations provide a body of knowledge that frames the skills, knowledge, and attitudes needed for entry into and conduct of professional practices (American Society of Civil Engineers, 2008; Association of University Technology Managers, 2016a; Project Management Institute, 2013). Professional organizations provide (a) standard vocabulary, (b) processes, and (c) professional development within a formal community of practice (American Society of Civil Engineers, 2008; Association of University Technology Managers, 2016a; Project Management Institute, 2013).

The technology transfer community of practice comprises four key professional organizations: the Association of University Technology Managers (AUTM), the Alliance of Technology Transfer Professionals (ATTP), the Licensing Executive Society (LES), and the Project Management Institute (Lovejoy, 2006; Project Management Institute, 2016a). According to Kerzner (2009), one professional practice that supports multiple professions, including technology development is Project Management Professional PMP.

The Association of University Technology Managers (AUTM) is a professional organization that supports the technology transfer community of practice. The mission of AUTM, as stated on their website, is to "support and advance academic technology transfer globally" (Association of University Technology Managers, n.d. [Mission statement.] Retrieved from www.autm.net/autm-info/). AUTM has developed a practice manual (Association of University Technology Managers, 2016b), the *AUTM Technology Transfer Practice Manual* (3rd ed.), in four volumes that cover a variety of topics ranging from laws and regulations to managing technology transfer offices, innovation, and

special technology transfer issues (Association of University Technology Managers, 2006).

The Alliance of Technology Transfer Professionals (ATTP) is a professional organization that provides education and development in support of moving technology to commercialization (Alliance of Technology Transfer Professionals, 2016a). ATTP provides the internationally-recognized Registered Technology Transfer Professional (RTTP) certification (Alliance of Technology Transfer Professionals, 2016b). The RTTP is a certification that distinguishes transfer professionals who have demonstrated requisite skills, knowledge, and expertise in technology transfer practices (Alliance of Technology Transfer Professionals, 2016b).

The Licensing Executive Society (LES) promotes the professional development of intellectual property professionals (Licensing Executive Society, 2016a). LES provides a Certified Licensing Professional (CLP) certification (Licensing Executive Society, 2016a). The CLP is recognized in the technology transfer community of practices as a certification awarded to transfer professionals who demonstrate an understanding of how to license intellectual property to commercial organizations (Licensing Executive Society, 2016b).

The Project Management Institute (PMI) is a professional organization that provides professional education, development, and specialized certifications for project, program, and portfolio managers (Project Management Institute, 2016a). Project management practices have application in industry, academia, and government research organizations (Project Management Institute, 2013; Kerzner, 2009; Wysocki, 2012). PMI (2016b) provides eight project management certifications, (a) Project Management

Professional (PMP), (b) Program Management Professional (PgMP), (c) Portfolio Management Professional (PfMP), (d) Certified Associate in Project Management (CAPM), (e) PMI Professional in Business Analysis (PMI-PBA), (f) PMI Agile Certified Practitioner (PMI-ACP), (g) PMI Risk Management Professional (PMI-RMP), and (h) PMI Scheduling Professional (PMI-SP) (Project Management Institute, 2016b). The certifications are presented to project management practitioners who demonstrate the skills, knowledge, and attributes required for each of the selected certifications (Project Management Institute, 2016b). Project management practices support a broad range of communities, including the research and development field.

Competency Models

As noted earlier, skills, knowledge, and select characteristics are an important aspect of shaping successful projects (Project Management Institute, 2013; Ruyle & Orr, 2011; Sanghi, 2007), and competency models help to frame the skills, knowledge, and characteristics needed to complete a project. Competencies, coupled with attitudes, behaviors, and abilities, are an important aspect of individual and project team development (Project Management Institute, 2007; Winterton, 2008). Rogers et al. (2001) highlighted that the application of technology transfer knowledge is important to successfully manage technology transfer activities. Competency development in the technology transfer project manager role is important to the success of the transfer process (Rogers et al., 2001).

This section highlights four competency models that support this research study. The models provide guideposts that can support the work of technology transfer project managers in nonprofit research organizations. The four competency models are drawn

from four standing professional bodies: the Project Management Institute, the Association of Talent Development, the American Society of Civil Engineering, and the Association of University Technology Managers. The competency models can serve as a frame of reference for the competency models of technology transfer project managers in nonprofit research organizations in Missouri.

Project Management Competency Development Model

The project management competency development (PMCD) model, developed by the Project Management Institute, provides one framework to guide project managers in their personal and organizational development. The PMCD model identifies skills, knowledge, personal characteristics, and attitudes that increase the likelihood of successfully completing projects and meeting stakeholders' expectation and requirements (Project Management Institute, 2007). This model incorporates three competency dimensions, (a) knowledge, (b) performance, and (c) personal (Project Management Institute, 2007). The knowledge competency focuses on understanding the specific knowledge areas, process groups, and tools used in project management (Project Management Institute, 2007). It can be assessed in the Project Management Professional (PMP) Examination. Performance competency centers on understanding the actions and outcomes of projects (Project Management Institute, 2007); it can also be assessed through the PMP Examination (Project Management Institute, 2007). Personal competency concerns the project manager's behavior in conducting projects (Project Management Institute, 2007). In addition to the three base competencies, the Project Management Institute (2007) identifies complementing competencies that include industry-specific and organizational competencies to support a broader application of

project management, as shown in Figure 3. The PMCD model can be used as an assessment framework for determining areas of improvement between current and desired competencies for project managers (Project Management Institute, 2007).

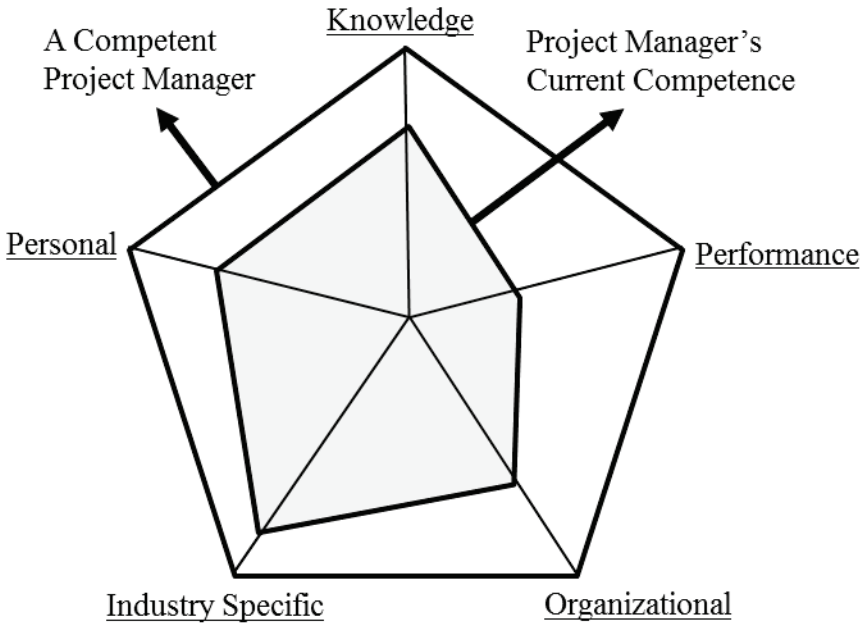

Figure 3. The project management competency development model. This model frames the three base competencies of knowledge, performance, and personal, and complements them with industry-specific and organizational competencies. The model also provides an assessment of current-to-desired competencies. From "Complementing the PMDC Framework," by the Project Management Institute, 2007, Project Manager Competency Development (PMCD) Framework (2nd ed.), p. 4. Copyright 2007 by the Project Management Institute. Adapted with permission.

Talent Development Competency Model

The Association of Talent Development (ATD) competency model provides a foundation for the talent development profession and highlights the competencies necessary for success in the talent development industry (Association for Talent Development, 2016). The model encompasses 10 areas of expertise and six foundational competencies, as shown in Figure 4 (Association for Talent Development, 2016). The 10

areas of expertise are (a) performance improvement, (b) instructional design, (c) training delivery, (d) learning technologies, (e) evaluating learning impact, (f) managing learning programs, (g) integrated talent management, (h) coaching, (i) knowledge management, and (j) change management (Association for Talent Development, 2016). The areas of expertise are supported by the foundational competencies focused on (a) business skills, (b) global mindset, (c) industry knowledge, (d) interpersonal skills, (e) personal skills, and (f) technology literacy (Association for Talent Development, 2016). The ATD competency model provides the framework for current and future talent developers in the profession.

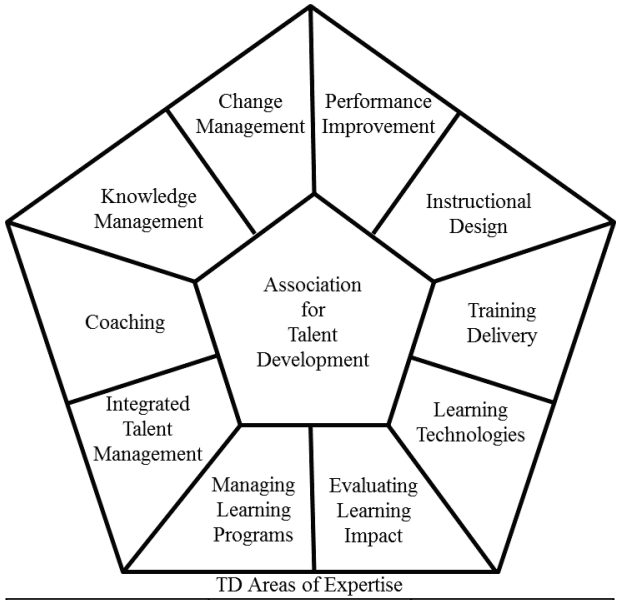

Figure 4. Association for Talent Development competency model. This model encompasses 10 areas of expertise, which are supported by six foundational competencies. From "The Association for Talent Development model," by Association for Talent Development, 2014. Retrieved from https://www.td.org/Certification/Competency-Model. Copyright 2014 by the Association for Talent Development. Adapted with permission.

Civil Engineer Competency Model

The civil engineer competency model provides a structure to guide civil engineers in their personal and professional development. The competency model addresses multiple expectations and expresses the outcomes in a rubric format (American Society of Civil Engineers, 2008). The competency model is structured with three major categories that contain 24 outcomes or competencies expected of civil engineers for entry into the professional level, as shown in Figure 5 (American Society of Civil Engineers, 2008). The competencies or outcomes are supported through (a) education in an Accreditation Board for Engineering and Technology (ABET) accredited bachelor's program that provides the foundation for all outcomes and a master's program for specialization, and (b) engineering experiences (American Society of Civil Engineers, 2008). The three major categories presented are foundational, technical, and professional (American Society of Civil Engineers, 2008). The outcomes or competencies are shown in Figure 5. According to the American Society of Civil Engineers (2008), the rubric frames the personal and professional competencies expected in the body of knowledge (BOK). The American Society of Civil Engineers (2008) BOK provides a development pathway for civil engineers within the community of practice.

Outcome Number and Title	Level of Achievement					
	1	2	3	4	5	6
	Knowledge	Compre-hension	Application	Analysis	Synthesis	Evaluation
Foundational						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
Technical						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M/30	
8. Problem recognition and solving	B	B	B	M/30		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. issues & hist. perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth in civil engineering areas	B	B	B	B		
15. Technical specialization	B	M/30	M/30	M/30	M/30	E
Professional						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Lifelong learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

Key:

B — Portion of the BOK fulfilled through the bachelor's degree

M/30 — Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses in a specialized technical area and/or professional practice area related to civil engineering)

E — Portion of the BOK fulfilled through the prelicensure experience

Figure 5. American Society of Civil Engineers rubric. The rubric frames three major categories that contain 24 outcomes or competencies expected of civil engineers for entry into the professional level. From "Civil Engineering Body of Knowledge for the 21st Century (2nd ed.)," by American Society of Civil Engineers, 2008. Retrieved from http://www.asce.org/uploadedFiles/Education_and_Careers/Body_of_Knowledge/Content_Pieces/body-of-knowledge.pdf Copyright 2008 by the American Society of Civil Engineers. With permission from ASCE.

Technology Transfer Professional Competencies

The AUTM Technology Transfer Practice Manual (TTP) is a multi-volume reference that provides information on a broad range of technology-transfer-related topics, one of which is desirable competencies for managers that practice technology transfer. The topics of the AUTM-TTP include laws and regulations, management in technology transfer offices, management of innovation, and special issues (Association of University Technology Managers, 2006). Competency models can take multiple forms, such as the competencies highlighted earlier in this section from the Project Management Institute, Association of Talent Development, and the American Society of Civil Engineers. The AUTM-TTP highlights skills, attributes, and desirable backgrounds that support the foundation of competencies needed for practicing in the technology transfer arena. Guay (2006) frames a matrix that builds on the skills and attributes highlighted by Weeks (2006), which are used in managing technology organizations, and he includes additional elements in the technology transfer arena to assist human resource managers in recruiting personnel for technology transfer positions. There are eight focus areas highlighted by Guay that are desirable in hiring technology managers: (a) communication, (b) creativity, (c) customer service/salesmanship, (d) facilitation, (e) multitasking, (f) diplomacy/political acumen, (g) technical expertise, and (h) teamwork skills (Guay, 2006). The eight technology transfer skills and attributes desired in the technology transfer arena are shown in Figure 6.

Examples of Skills for Technology Managers	Examples of Associated Attributes	Examples of Related Experience
Communication	Outgoing, good listener, strong command of required languages (written and spoken), empathy	Has successfully communicated with multiple stakeholder groups
Creativity	Participates in extracurricular activities, independent, self-motivated	Has problem solved as part of a technical or project-based initiative
Customer service/salesmanship	Friendly, honest, invests in others, goal-oriented, perceptive	Has worked in customer service, in a sales environment (retail and restaurant experience count)
Facilitation	Patient, identifies objectives clearly, can role play, strong command of required languages	Has taken on leadership roles and led group decision making
Multitasking	Self-directed, able to prioritize	Has worked in an environment that required managing multiple priorities
Diplomacy/political acumen	Can role play, empathetic, good listener, strong command of required languages	Has formally represented a cause or organization through a transition, change, or challenge
Technical expertise	Analytical, active learner	Has education and applied experience in the required area of technical expertise
Teamwork skills	Cooperative, able to put the goals of team before personal agendas	Has worked in a team environment where the team members were jointly responsible for the deliverables

Figure 6. A summary of beneficial skills, attributes, and related experience for technology transfer professionals. From *Recruiting and retention strategies for technology managers*, by L. N. Guay, 2006, in Association of University Technology Managers, *Technology Transfer Practice Manual*, Volume 2, Part 1, Chapter 6.1, p. 6, Oakbrook Terrace, IL: Association of University Technology Managers. Copyright 2006 by Association of University Technology Managers. Reprinted with permission.

In addition to Guay's (2006) matrix of desirable skills, attributes, and experiences, Rasor and Heller (2006) identify desirable skills, knowledge, and attributes for technology transfer professionals. The skills, knowledge, and attributes highlighted by Rasor and Heller complement the elements listed by Guay but provide a broader contextual framework that focuses on having background experience in three broad areas

within the technology transfer community of practice. The three background areas in the technology transfer community are (a) technical, (b) business, and (c) legal. Rasor and Heller highlight desired competencies as outlined in the AUTM-TTP and as shown in Table 1.

Table 1
Desirable Backgrounds and Knowledge of Licensing Staff Personnel

Desires	Description
Technical Background	The understanding of technology and innovation and the ability to communicate with faculty.
Business Background	The ability to speak with industry and understand how to close a licensing deal.
Knowledge of Applicable Law	The ability to understand intellectual property terms and contractual conditions.

Note. This table provides a summary of the desirable characteristics of technology transfer staff members, as described by Rasor and Heller (2006, p. 7) in the Association of Technology Managers Technology Transfer Practice Manual.

The skills, knowledge, and attributes outlined by Guay (2006), Weeks (2006), and Rasor and Heller (2006) provide general guidelines for desired competencies in practitioners and managers working in the technology transfer community. This section summarized four competency models from the Project Management Institute, Association of Talent Development, American Society of Civil Engineering, and Association of University Technology Managers. The competency models, charts, and table support this

research study by providing a frame of reference for technology transfer project managers in nonprofit research organizations. The next section focuses on a literature review of case study, which is the methodology used for this research.

Case Study

Case study is a qualitative research methodology. Early researchers such as Lincoln and Guba (1985) noted that the more traditional method of research, quantitative methodology, was too confining and limited other perspectives. Using words rather than numbers, qualitative research is a form of inquiry that provides researchers with the opportunity to study people and their perspectives in their real-world activities. Qualitative research focuses on understanding the socially constructed reality from a close relationship between the participant and the researcher in a real-life setting (Denzin & Lincoln, 2011). Knowledge of the philosophy, theory, and practices of the methodology can help researchers apply and analyze qualitative methods appropriate for their study (Creswell, 2013). This section summarizes the philosophy, theory, and practices of qualitative research in an effort to provide the rationale for selecting a case study, which is the method used for this research.

The philosophy of qualitative research states that the nature of reality (ontology) is made of multiple realities from individual perspectives and experiences and is supported by multiple forms of evidence (Denzin & Lincoln, 2011). Knowledge is developed (epistemology) through close interaction with the participants in the study (Denzin & Lincoln, 2011). The values of the researchers (axiology) are discussed as part of the assumptions in the study (Denzin & Lincoln, 2011). The procedures

(methodology) used in collecting and analyzing data are characterized as emerging from the data through the experiences of the researcher (Denzin & Lincoln, 2011).

Theory, a unified understanding of related discrete observations that provides an explanation (Patten, 2012), offers a framework to deepen understanding and build knowledge. The theory of qualitative research is that data and interpretation help to develop knowledge (Creswell, 2013). There are multiple theories used within the framework of qualitative research, such as (a) feminist theory, (b) critical theory, (c) critical race theory, (d) queer theory, and (e) disability theories (Creswell, 2013; Patton, 2002).

The practices of qualitative research consist of five general designs: (a) narrative, (b) phenomenology, (c) grounded theory, (d) ethnography, and (e) case study (Creswell, 2013; Patton, 2002). The focus of the narrative approach is to explore the life of an individual (Creswell, 2013; Patton, 2002). Phenomenology focuses on understanding the essence of lived experiences (Creswell, 2013; Patton, 2002). Grounded theory focuses on developing a theory based upon the field data (Glaser, 2010). The focus of ethnography is describing and interpreting the shared culture of a group (Creswell, 2013; Patton, 2002). Lastly, a case study focuses on providing an in-depth description and analysis of a real-life case in its context (Yin, 2014).

The case study research method centers on an in-depth examination of a phenomenon in its natural context. Crowe et al. (2011), as well as Yin (2014), have noted that a case study is a research approach that provides an intense description and analysis of a phenomenon bound by its real-life context. The purpose of a case study design is to answer the research question by exploring the *how* and the *why* of a select

group of individuals (Flyvbjerg, 2011; Yin, 2014). Thondhlana and Smith (2013), for example, used a case study approach to explore language usage in a complex task-based business project system.

Crowe et al. (2011) noted three types of case studies consisting of (a) intrinsic, (b) instrumental, and (c) collective. The intrinsic case study focuses on a single issue or phenomenon, while an instrumental case study highlights a particular case to illustrate the phenomenon (Crowe et al., 2011). The collective case study leverages multiple cases to capture a broader understanding of the phenomenon or issue (Crowe et al., 2011). Case study provides a method through which the researcher can explore the activities of people in a group in a close and in-depth way. The research method used for this research is a multiple case approach selected to capture a broader understanding of technology transfer project managers.

Focus

Creswell (2013) noted that the focus of a research method for a study is considered the primary objective. The focus of the case study method, as noted in the previous section, is to develop an intense description and analysis of a phenomenon bound by its real-life context (Creswell, 2013; Crowe et al., 2011; Yin, 2014). Similarly, the focus of the phenomenology method is to understand an individual's experience by exploring the essence of the phenomenon (Creswell, 2013). The focus of the grounded theory method is to understand common social circumstances and to produce a theory based on the data (Glaser, 2010). Understanding the focus of the methods can help in selecting the best method for identifying the project manager competencies supporting technology transfer.

Unit of Analysis

Yin (2014) summarized the unit of analysis as the *case* (the individual or individuals) and its *boundaries* (the type of phenomenon, time, and/or location). The unit of analysis for a case study method centers on an activity or a group (Creswell, 2013). Phenomenology frames the unit of analysis as understanding the experiences of several individuals (Creswell, 2013). Lastly, the unit of analysis for grounded theory method focuses on an interaction from the perspective of multiple individuals (Creswell, 2013). Understanding the unit of analysis helps to determine which methods are best suited to identifying the project manager competencies required to support technology transfer.

Data Collection

Data collection focuses on the processes through which the three methods gather information for research. Data collection methods may consist of interviews, surveys, and observations (Pannucci & Wilkins, 2010). Those that support case study may consist of interviews, documents, and observations (Yin, 2014). Phenomenology data collection relies primarily on interviews, but may include other forms such as documents and observations (Creswell, 2013). Finally, grounded theory leverages interviews of individuals in medium and large groups (Creswell, 2013; Glaser, 2010). The preferred methods of data collection provide an understanding that helps to shape the selection of the method best suited to identifying the project manager competencies required to support technology transfer.

Advantages

The advantages of using case study to explore the business competencies supporting technology transfer are the ability to (a) describe in detail the phenomenon of

technology transfer and necessary competencies, and (b) select between intrinsic, instrumental, or collective case studies in order to support the research (Crowe et al., 2011). As noted earlier, Thondhlana and Smith (2013) used case study to explore project system languages. The advantage of using phenomenology to understand the project manager competencies supporting technology transfer is the ability to understand the experiences of people conducting technology transfer (Ehrich, 2005). The advantage of using grounded theory to understand the business competencies supporting technology transfer would be to develop a theory on the business competencies needed to support technology transfer (Glaser, 2010).

Disadvantages

The disadvantages of using case study to explore the project manager competencies supporting technology transfer are (a) lack of rigor and (b) force-fitting of findings to a particular theoretical framework (Crowe et al., 2011). The disadvantage of using phenomenology is that this method would be limited in providing an understanding of the experiences associated with the project manager competencies supporting technology transfer (Creswell, 2013). The focus of the research is to identify the project manager competencies. The disadvantage of using grounded theory is that the method requires a great deal of time in order to develop a theory; this may not be best suited to support the requirement of identifying the project manager competencies (Hunter, Murphy, Grealish, & Keady, 2011).

Sample Selection

Two key considerations in sample selection are sample representation and sample size. Sample representation involves identifying the characteristics of the population to

be researched. Patton (2002) noted that a representative sample shapes the data for the research. Reybold, Lammert, and Stribling (2012) reinforced this point by noting that the researcher consciously selects a population that meets the characteristics that support the focus of the study. Sample size refers to the number of data collections needed, for example, the number of people to interview, before the data becomes *saturated* (Marshall, Cardon, Poddar, & Fontenot, 2013). Saturation refers to the point at which no new themes are emerging from the depth and breadth of data, and all categories are recognized (O'Reilly & Parker, 2012). The sample size in qualitative research is not a fixed number; it may range from one to 50, depending on the method and the phenomenon (O'Reilly & Parker, 2012).

A case study focused on identifying the business competencies supporting technology transfer may use a purposefully selected representative sample of people who practice technology transfer as part of an R&D business, for example, R&D project managers in a nonprofit research organization. The sample size may need to include 10-30 participants to achieve saturation in identifying the business competencies supporting technology transfer (Marshall et al., 2013; O'Reilly & Parker, 2012). Mitigation strategies to support a case study focused on identifying the business competencies needed for technology transfer would be to consider (a) sample representation and (b) sample size, which are components of the foundation for validity in qualitative research.

Validity

Validity in qualitative research anchors sample selection, data collection, interpretation, and conclusion. Lincoln and Guba (1985) define validity as the trustworthiness of the research, and identify (a) credibility, (b) authenticity, (c)

transferability, (d) dependability, and (e) conformability as factors to consider within the qualitative research framework. Validity permeates activities throughout the research process, such as (a) taking care in constructing the data collection instrument, (b) selecting the population, (c) collecting the data, (d) interpreting the results, and (e) developing a conclusion based on the data (Patton, 2002).

Validation strategies used to support case study can take multiple approaches. One strategy to support case study is thick description and member-checking to support credibility (Creswell, 2013; Patton, 2002). A second is to summarize the *bounds* of the case, elements of data specific to the phenomenon, with sufficient description to allow the reader to transfer or assess fitness of the research to similar technology transfer processes (Patton, 2002; Yin, 2014). A third considers (a) appropriate design, (b) procedures, (c) custody of the data, (d) the audit trail, (e) interpretation, and (f) in-depth description of the context to demonstrate dependability (Morse, Barrett, Mayan, Olson, & Spiers, 2002; Yin, 2014). A fourth strategy is incorporating (a) credibility, (b) dependability, (c) confirmability, and (d) transferability into the procedures and standards of the case study to establish trustworthiness (Marshall & Rossman, 2011). A fifth strategy involves triangulation of the data; the use of automated qualitative software in analyzing the coding helps to maintain validity (Yin, 2014).

Bias

Bias is a tendency or perspective that prejudges data or a consideration in research. Pannucci and Wilkins (2010) noted that bias, a preconceived notion of the outcome of an activity, can occur throughout the research process. Bias can be found in (a) design selection, (b) study-population selection, (c) data collection, (d) data analysis,

or (e) recall of information in writing the study (Pannucci & Wilkins, 2010). As such, researchers need to control for bias in all phases of their research by taking steps to mitigate bias through rigorous research procedures (Patton, 2002).

The potential biases associated with a case study on identification of business competencies supporting technology transfer are a familiarity with (a) R&D projects and (b) research project managers. One approach to mitigating the potential bias is through *bracketing* and self-disclosure (Bednall, 2006; Patten, 2012). Bracketing is an understanding of which experiences the researcher brings into the data collection and how the researcher's personal experiences influence the interpretation of the data, and a means of stepping back from the data to determine if there are any influences that are being placed on the data (Bednall, 2006). Self-disclosure and transparency can help researchers to avoid potential bias in data collection, analysis, and conclusions (Patten, 2012; Yin, 2014). For a case study focused on identifying the business competencies required to support technology transfer, bias can be controlled by working with only the project managers who meet the selection criteria; in this case, that of having experience with technology transfer in a business environment. Another approach to controlling bias is to use multiple case studies to highlight business competencies in the technology companies, by providing the depth needed to understand the phenomenon of technology transfer (Yin, 2014). A third approach is to understand the personal biases of the researcher within the context of the research (Creswell, 2013).

Sample selection, validity, and bias are important aspects of qualitative research. This section analyzed the issues of sample selection, validity, and bias from the context of a case study, which was selected as the method best suited for this research on

identifying the project manager technology transfer competencies required to move technology innovation from the R&D lab into the marketplace.

Conclusion

This chapter provided an overview of literature focused on (a) expert performance, (b) decision making, (c) learning models, (d) project management competencies, (e) self-efficacy, (f) technology transfer, (g) nonprofit research organizations, and (h) the use of case study methodology to support this research. The literature review drew on four broad fields of (a) project management, (b) talent development, (c) civil engineer development, and (d) technology transfer to guide the exploration of the required competencies for project managers focused on technology transfer processes in nonprofit research organization. A key consideration in selecting a method centers on the focus of the research and how best to collect and analyze the data to meet the objective of the research (Creswell, 2013). This chapter provided background on (a) narrative, (b) phenomenology, (c) grounded theory, (d) ethnography, and (e) case study methods. This chapter also provided the rationale for selecting case study methodology as that best suited for identifying the project manager competencies required to move technology innovations from the R&D laboratory into the marketplace. The next chapter describes the methodology used for this research, highlighting the approach used in collecting and analyzing the data.

CHAPTER 3. METHODOLOGY

This chapter describes the qualitative multiple-case-study methodology the researcher used to explore the competencies of project managers in nonprofit research organizations. This chapter first reviews the purpose and the research question. Secondly, it describes (a) the research design, (b) sample, (c) setting, (d) instrumentation, (e) data collection, (f) data analysis, (g) validity and reliability, and finally (h) ethical considerations. This chapter outlines methodology used in this study and shapes the framework for the following chapter, which focuses on the results of the study, and the final chapter, which offers discussion, implications, and recommendation.

Restated Purpose

The purpose of this multiple-case study was to describe the experiences and perceptions of project managers regarding competencies needed to support the process of technology transfer in four nonprofit research organizations in Missouri. The research used semi-structured one-on-one interviews, biographical information, and direct observations (Baxter & Jack, 2008; Creswell, 2013; Patton, 2002; Yin, 2014). As described earlier, technology transfer competencies are defined as the knowledge and skills needed to manage the movement of technology from the laboratory to a commercial organization (Creswell, 2013; Fuller & Hahman, 2010; Speser, 2006; White & Bruton, 2011; Yin, 2014). The researcher intends to fill the gap in knowledge that currently exists in the body of knowledge of the Research and Development (R&D)

technology transfer project manager community (Rogers et al., 2001). Maryman's (2011) research on the impact of the project knowledge areas on information technology manufacturing and Rhodes' (2014) research on selection and orientation of members in nonprofit organizations are extended with this study. This study has also laid a foundation for continued research and support of technology transfer project management and the sharing of best practices in nonprofit research organizations.

Research Question

What are the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations?

Research Design

The research approach leveraged a multiple-case-study design that used an extreme-case sampling method to explore the experiences of R&D project managers who practice technology transfer activities in nonprofit research institutions (Baxter & Jack, 2008). An extreme case study focuses on unusual or extreme variations of a phenomenon (Creswell, 2013; Yin, 2014). The researcher selected extreme cases to highlight project managers who are extremely successful in technology transfer practices in order to describe the unusually successful competency model for project managers in four nonprofit research organizations (Yin, 2014). The researcher used a data collection method that leveraged semi-structured interviews, biographical data, and observations from technology transfer project managers in Missouri (Yin, 2014). A high-quality analysis in a case study (multiple and single) should (a) focus on pertinent evidence to address the research question, (b) address rival interpretations of the findings, (c) focus

on the most significant issue rising from the data, and (d) include prior and expert knowledge of the topic (Yin, 2014). The researcher analyzed the participant interviews, documents, and observations using a computer-assisted qualitative data analysis software known as NVivo 11 to identify themes as shown in Figure 7 (Weitzman, 2000; Yin, 2014), and used individual organizations as the unit of analysis.

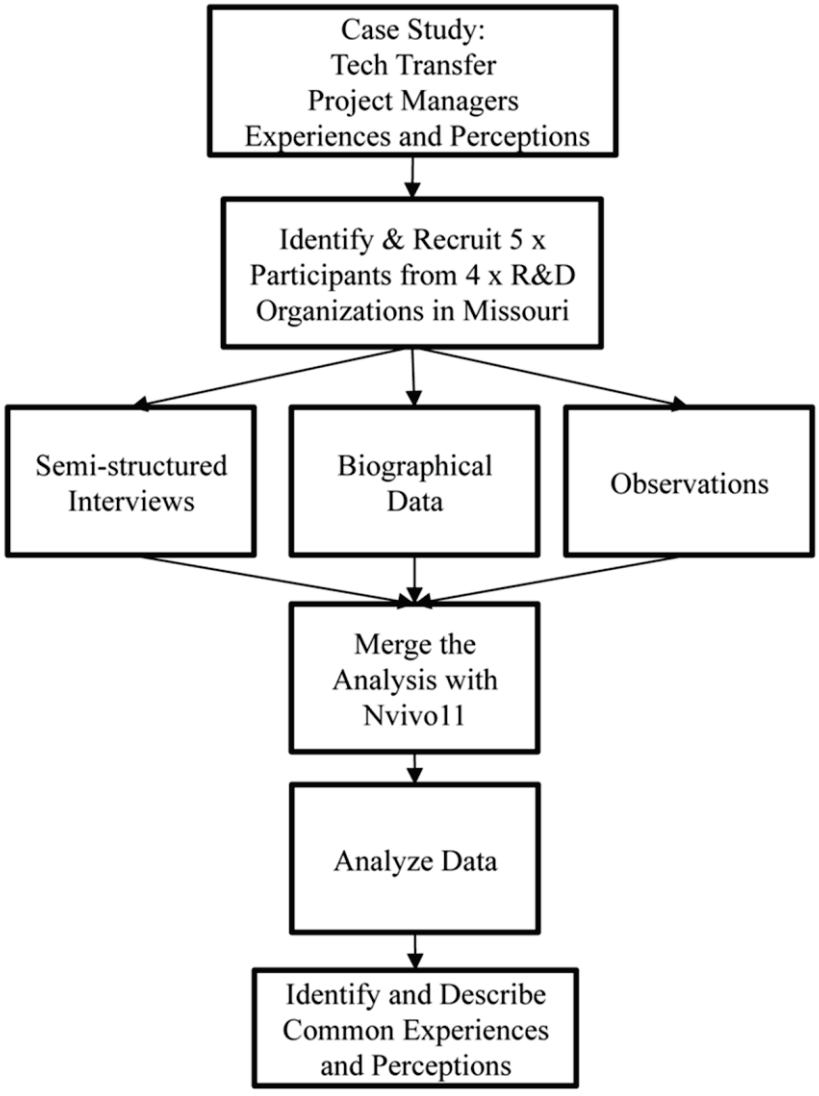

Figure 7. Research methodology. This figure incorporates research methodologies highlighted by Creswell (2013) and Yin (2014).

The research design for this research project used a purposive multiple-case-study approach leveraging semi-structured one-on-one interviews, biographical information, and observations. The study population consisted of research and development project managers in nonprofit research institutions. The sample was selected from a group of volunteers who are members of technology transfer organizations in Missouri. The purposive sample was chosen based upon responses to questions about experience with technology transfer.

The interviews were conducted by leveraging open-ended interview techniques using a digital recorder in the participant's office or in a private meeting room, over a 60-minute period and using a standard set of questions (Patten, 2012). Upon completion of the interview, the participant provided a biographical document summarizing his or her education and management assignments prior to being assigned to his or her technology transfer position in the nonprofit research institution. In an effort to bracket information on opinions and biases, the researcher highlighted his prior research and development project activities in both the public and private sector (Bednall, 2006). The researcher continued to conduct interviews until saturation on the topic was obtained, as recommended by Yin (2014). The researcher also captured personal research thoughts in a memo notebook during data collection, coding, and analysis in order to deepen the analysis (Bednall, 2006).

The research approach leveraged a purposive multiple-case-study design. The researcher utilized an extreme-case sampling method consisting of an empirical homogeneous purposive sample to explore the experiences of nonprofit research and development project managers who focus on technology transfer activities (Baxter &

Jack, 2008; Patton, 2002; Yin, 2014). The holistic design was selected due to the general focus on technology transfer project managers, as noted by Yin (2014). The expected outcome was a clearer understanding of project manager competencies needed to be a successful technology transfer project manager in a nonprofit research institution. Describing the competencies required to program and integrate technology activities provided information that fills a gap in knowledge that currently exists in the research and development project manager community body of knowledge (Boehm & Hogan, 2014; Rogers et al., 2001).

Sample

The sample population for the research comprised project managers from four nonprofit research organizations in Missouri. Each of them has been extremely successful in transferring an innovation from the research and development laboratory to a commercial organization for market production. The population consisted of men and women experienced in the practice of technology transfer. The population was selected from among volunteer participants who are employed by one of four nonprofit research institutions in Missouri.

The sampling frame, or bounds, for this purposive sample were drawn from research and development project managers. Ellinger, Watkins, and Marsick (2005) noted that the bounds of a case study are framed around an individual, a group, or an organization. The sample bounds were the nonprofit research organizations. Once the sample was refined, the researcher interviewed the purposive sample of the extremely successful research and development project managers in technology transfer practices.

Orcher (2005) highlighted three considerations in selecting participants in purposive sampling, consisting of (a) establishing individual selection criteria, (b) reasoning for establishing the criteria, and (c) ensuring that these selected individuals are contacted for the study. The first specific purposive-sample consideration for this sampling frame was selecting research and development project managers, also known as technology transfer professionals, working in nonprofit research and development organizations. The second consideration was that the specific participants were considered to be successful in technology transfer of research and development innovation to commercialization. Finally, the researcher confirmed that the participants were available for interviews and observations, and had the necessary historical documentation to support the case study.

The sample size was intended to be 20-30 research and development project managers. The initial sample was similar to that of research described by Bernard and Ryan (2010). The actual size was smaller as the information from the interviews began to saturate the retrieved data (Bernard & Ryan, 2010). Bernard and Ryan noted that a small empirical homogeneous purposive sample would likely saturate at a lower number.

The selection procedures were similar to case studies as noted by Bernard and Ryan (2010), Creswell (2013) , and Yin (2014). The background and selection of the research and development project managers provided the necessary information specifically focused on technology transfer practices. The sample size and anticipated saturation point was similar to research as noted by Bernard and Ryan.

Recruitment for this research began with obtaining permission from the four nonprofit research organizations. The research organizations are referred to as (a)

Research Site 1, (b) Research Site 2, (c) Research Site 3, and (d) Research Site 4, all located in Missouri (Salmons, 2010). Permission was granted by the organizations, and an email outlining the focus of the study was sent to the research and development project managers (Salmons, 2010). The researcher contacted for the study a purposive selection of 20 project managers who have experience in successful technology transfer; he then provided and processed consent forms (Orcher, 2005).

Setting

The setting for the data collection was at each respective participant's place of employment, with the consent of the supporting organization. The one-on-one semi-structured interviews were conducted in the participant's office or in a private meeting room within the organization's office space, over a 60-minute period using a standard set of questions (Patten, 2012). The interviews were digitally recorded for accuracy. Through observation, the researcher collected information on the physical layout of the office or private meeting room, and referenced charts or recommended texts from the common office reference library. Additionally, field notes were taken during and following each interview, focusing on responses and impressions from each participant (Bednall, 2006). Prior to departure from the participant's organization location, the researcher paused and reflected to capture thoughts through memos, as recommended by Bednall (2006).

Instrumentation

The researcher's role within the framework of the in-depth interviews in the case study was to function as the data-gathering instrument (Marshall & Rossman, 2011). The interviews, coupled with the biographical data, provided another source of information

for which the researcher was responsible (Creswell, 2013). The researcher was cognizant of the position in which he entered the lived experience of the participant (Marshall & Rossman, 2011). While maintaining the focus on the research, the researcher was respectful of the participants' time, and efficient in conducting the interviews and in pursuing any necessary follow-up information (Marshall & Rossman, 2011).

Data Collection

Data collection in the one-on-one semi-structured interview consisted of 12 open-ended survey questions. Questions 1-3 were intended to establish a rapport with the research and development project manager (Patten, 2012). Questions 4-6 provided necessary demographic information about the participants, which applies to the development of the project managers (Patten, 2012). Questions 7-12 were predetermined and open-ended. The questions guided the interview conversation and focused on the central phenomenon in the study—the skills, knowledge, and abilities of the research and development project managers conducting technology transfer activities (Creswell, 2013; Patten, 2012). Five data collection instruments were used for the case study, consisting of (a) semi-structured interviews with guide, (b) biographical data, (c) observations, (d) research notes, and (e) research memos.

Semi-Structured Interviews

The semi-structured interview with guide provided the framework for the collection of data from each participant through a consistent series of open-ended questions, as shown in Appendix A. The guide and framework were adapted from Patten's (2012) guide and framework; however, the questions were modified to meet the data collection for this research. The questions were designed around examples provided

by Patten (2012) and Creswell (2013). The semi-structured interview provided data from each of the participants that described their experiences based on the questions asked (Patten, 2012).

Field Testing

The field testing for data collection consisted of requests for feedback on the interview questions, as well as on the technique and tone used while conducting the interview using the semi-structured interview protocol (Patten, 2012; Salmons, 2010). The field test provided two elements of information efficiently and concurrently. The first element was feedback on the questions in the survey. The second element was the technique used by the researcher during the interview. This feedback was incorporated into the content of the questions and into the protocol for the interview.

The field test was conducted using a convenient sample of three people selected based on their experience in (a) research, (b) technology transfer, and (c) business, and their ability to provide candid feedback regarding the semi-structured survey questions and protocol (Yin, 2014). The field test participants had backgrounds in (a) research engineering, (b) technology evaluations, (c) technology protocols, (d) research methodologies, and (e) business. The participants in the field test had no direct relationship with the subject organizations (Yin, 2014). The field test feedback provided information on the survey questions as well as on the technique, all of which were incorporated into the interview questions provided in Appendix A.

Biographical Data

Biographical data was provided by the research and development project managers from their resumes and highlighted their experience and education in research

and development project management. Collecting biographical data, as an instrument from the project managers, added depth to the background of the participants and to the context of the interview and the study (Creswell, 2013).

Observations

Direct observation, as an instrument, provided the researcher with data concerning job activities and processes and references made by the research and development project managers in the technology transfer processes (Creswell, 2013; Rogers et al., 2001; Yin, 2014). Observations consisted of direct spot-data collection with the participant, which added depth in understanding the processes and practices (Bernard & Ryan, 2010). The observational field note design is an adaptation of the design developed by Marshall and Rossman (2011)

Research Notes

Research notes were an important part of the research. Notes were taken during and following each interview; they focused on impressions, questions, or comments, and aided in bracketing perceptions from the information gleaned (Bednall, 2006; Marshall & Rossman, 2011). The research notes from the interviews were then added to the database as part of the collected documents (Bednall, 2006; Marshall & Rossman, 2011).

Research Memos

Research memos are also an important data source during research. Research memos were taken during the data collection in an effort to capture the researcher's thoughts on potential themes or ideas that emerged from the data (Bednall, 2006). Research memos differ from research notes in that memos are researcher's personal

reflections on concepts and categories emerging from the data and potential categorical relationship (Bednall, 2006). The data from the research memos was added to the database for analysis.

Data Analysis

Analyzing case study evidence is challenging, and Qualitative Data Analysis Software (QDAS) tools such as Atlas.ti, HyperRESEARCH, and NVivo can help in digesting the large volumes of collected data (Yin, 2014). The analysis of the data for this multiple-case study used a strategy that leverages a *theoretical proposition* approach, as noted by Yin (2014). The theoretical proposition strategy orients on the objectives of the case study and helps frame the analysis based on the proposition that shaped the study (Yin, 2014). In this multiple-case study, themes that focused on the skills, knowledge, and abilities of research and development program managers were explored.

The analysis leveraged NVivo 11 software's *word frequency* tool to gain pattern matching from the data. Pattern matching focuses on the number of times a specific word occurs in a given text (Yin, 2014). Pattern matching is one of the most preferred analysis techniques (Yin, 2014). Using NVivo 11 helped to organize and manipulate the data in order to develop themes from the data (QSR International, 2016a).

Audio recordings were transcribed through Dragon NaturallySpeaking, an audio-to-text conversion software, and the text was loaded into NVivo 11 for pattern-matching analysis (Nuance, 2014; QSR International, 2016a; Yin, 2014). Likewise, all text (interview text, personal documents, memos, and notes) data were loaded into the NVivo 11 for pattern-matching analysis (QSR International, 2016a; Yin, 2014). Using NVivo 11 assisted the researcher in organizing the data in order to draw out themes and patterns

from the text in the software (QSR International, 2016a). The competency themes highlighted by the analysis comprise the dominant competencies of the project managers conducting technology transfer processes (QSR International, 2016a; Yin, 2014). The flow of this process is consistent with similar case study methodologies highlighted by Yin (2014).

Validity and Reliability

Validity and reliability are cornerstones in qualitative research and they anchor (a) sample selection, (b) data collection, (c) interpretation, and (d) conclusion. As noted in an earlier chapter, Lincoln and Guba (1985) summarized validity as trustworthiness of the research and oriented on (a) credibility, (b) authenticity, (c) transferability, (d) dependability, and (e) conformability as terms within the qualitative research framework. Validity permeates the activities throughout the research process, such as taking care in constructing collection instruments, selecting the population, collecting and interpreting the data, and developing a conclusion based upon the data (Patton, 2002).

Validation strategies to support case study can take multiple approaches. The first strategy to support case study is thick description and member checking to support credibility (Creswell, 2013). A second is a clear summary of the bounds for the case, with sufficient description to allow the reader to transfer or find fitness of the research to similar technology transfer organizations (Patton, 2002). A third is appropriate design—following procedures, maintaining custody of the data, the audit trail, interpretation, and describing the context in-depth to demonstrate dependability (Morse et al., 2002; Yin, 2014). A fourth strategy is incorporating credibility, dependability, confirmability, and transferability into the procedures and standards of the case study to establish

trustworthiness (Marshall & Rossman, 2011). A fifth strategy involves leveraging triangulation of data and automated qualitative software in analyzing the coding (Yin, 2014).

To highlight the elements of trustworthiness as summarized by Lincoln and Guba (1985), credibility was achieved through thick description and member checking; two validation strategies as recommended by Creswell (2013) and Patten (2012). Transferability in this case study was focused on clearly summarizing the bounds of the case so the reader is more easily able to find fitness with the results of the research and apply it to similar technology transfer processes (Patton, 2002). Dependability was gained through an appropriate design, following procedures, maintaining custody of the data, the audit trail, interpreting, and describing the context in-depth (Morse et al., 2002; Yin, 2014). Trustworthiness was gained through incorporating (a) credibility, (b) dependability, (c) confirmability, and (d) transferability into the procedures and standard of the case study (Marshall & Rossman, 2011). Confirmability was gained through triangulation of the data and use of NVivo 11 in analyzing the coding (Creswell, 2009; Yin, 2014). Yin (2014) highlights four tests for judging the quality of research design. Three of the tests focus on construct validity, internal validity, and external validity; the fourth targets reliability (Yin, 2014). Yin (2014) summarized that construct validity uses multiple sources of evidence, establishes a custody change for the evidence, and allows for select informants to review the case study draft. A second test outlined by Yin (2014) in internal validity leverages pattern matching and explanation building, addresses rival explanations, and uses some type of logic model. A third test is external validity, which

focuses on a specific theory in a single case study and uses replication logic in multiple-case studies (Yin, 2014).

Reliability is the second cornerstone upon which research rests. Lincoln and Guba (1985) highlighted that reliability is similar to dependability and consistency and sets the conditions for validity. Additionally, reliability is gained by following procedures that support replication (Lincoln & Guba, 1985). Likewise, Yin (2014) highlighted reliability as the last of the four tests for judging the quality of research design. Following specific research and database protocols adds to reliability (Yin, 2014).

Ethical Considerations

Researchers have an ethical obligation to protect and reduce risk so no harm comes to the participants involved in a research project (Academy of Management, 2014; Bryant, 2005). An ethical consideration in the sampling procedures was that all of the research and development project managers in selected organizations who have successful experience in technology transfer organizations had an opportunity to participate in the case study (Creswell, 2013; Yin, 2014). All participants in the study signed an informed consent letter which outlined the purpose of the study and which stated that the information would remain confidential, that the data would be secured and retained for seven years by the researcher, and that it would then be destroyed (Academy of Management, 2014). As the population from the selected organizations for the study was voluntary, no type of incentive or stipend was provided (Creswell, 2013). An additional consideration was that the researcher had no influence or management

authority over any of the research and development project managers (Academy of Management, 2014; Bryant, 2005; Creswell, 2013).

The ethical considerations in this study focused on protecting the data collected from the participants. The interviews were kept confidential (Academy of Management, 2014). The researcher transcribed the recorded interviews and the transcriptions were reviewed by the participant to ensure accuracy as an element of member checking (Creswell, 2013). The data was safeguarded at the researcher's private office with access control to the computer and database through encryption to prevent unintended disclosure (Creswell, 2013). The level of risk to the participants from the interviews was minimal (Academy of Management, 2014). The interviews and observations were scheduled at a convenient time early in the day to reduce interruption during business activities (Marshall & Rossman, 2011).

CHAPTER 4. RESULTS

Introduction

This chapter presents the analysis of the data collected from exploring the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations. This chapter highlights (a) the background of the researcher, (b) description of the samples, (c) thematic analysis applied to the data, (d) data and analysis results, (e) competency themes, (f) lessons learned, and (g) summary.

Researcher Background

The researcher became interested in project management early in his military career in order to better plan, prepare, and conduct missions or projects as part of his military engineering duties. During his extensive military duties spanning over 20 years, the researcher supported multiple technology developments, technology demonstrations, and conceptual applications of technology for the Department of the Army. Following the researcher's military career, he managed and was the principal investigator for a small business innovation research (SBIR) team focused on developing new technologies.

The researcher's educational background includes a Bachelor of Science in Mathematics, a Master of Arts in Human Resource Development, and extensive coursework in an organization management doctoral program. Professionally he has completed multiple development courses in management, organizational development,

and leadership while serving in the United States Army Corps of Engineers. He was a soldier and is a leader with a deep background in professional and organizational development from operational and institutional assignments.

The researcher for this case study has had formal training in conducting in-depth interviews and in using qualitative analysis software. The researcher's experience stems from fundamental training in observing training programs at three of the four U.S. Army's military training centers. The observation skills included (a) developing a training relationship with military organizations at the training center, (b) asking select training questions of leaders and staff members in the organization, and (c) observing and providing feedback to leaders and all levels regarding the quality of training demonstrated in field and simulated-field environments. The researcher has foundational training on a Qualitative Data Analysis Software (QDAS) system. As noted in Chapter 3, the QDAS selected for this research is NVivo 11. The selection was based on the explanation-building analytic technique used to categorize data for the research, and on the ease of coding text within the software, as highlighted by Weitzman (2000). The researcher completed self-directed learning on NVivo 11 from the NVivo online training site (QSR International, 2016a).

The researcher's scientific philosophical assumptions straddle both positivism and interpretivism, in that he appreciates the measured approach to causal relationships in the world as well as social meanings within the context of a community (Gephart, 1999; Lincoln, Lynham, & Guba, 2011). The researcher currently serves as a director and program manager for a large public government engineering-education organization in Missouri.

The researcher's interest in technology transfer and nonprofit research organizations began when he was serving in the U.S. Army and increased when he was managing an SBIR team following his military service. While managing the SBIR, the researcher was introduced to nonprofit research organizations and the practices needed to effectively manage the technology under development by his SBIR team. Many of the personal-knowledge, performance, and organizational skills necessary for success as a leader in the U.S. Army were transferable to his work with the SBIR team. However, new skills in technology transfer, research and development, and project management were needed to manage the new SBIR technology team, its requirements, and project objectives. The researcher engaged in self-directed studies in multiple areas including physics, business fundamentals, and contract law. The researcher continues to enjoy exploring and supporting new technologies as part of his current position and as a member of professional organizations that focus on the development of science, technology, engineering, and mathematics (STEM) programs in his local community.

The researcher is no longer a member of the SBIR team nor any nonprofit research organizations, beyond that of a supporter for their STEM contributions to the field of technology transfer and project management. He is a member of the American Society of Engineering Educators (ASEE), ATD, AUTM, and PMI, all of which have influenced the perspective and provided background information for this study. The researcher's interests in this study are strictly from an outside, third-party perspective. During this study, the researcher had the privilege of interviewing and observing 10 project managers, also titled as technology transfer professionals, who manage key

processes and activities in the technology transfer process for their nonprofit research organizations.

Description of the Samples

The sample comprised project managers, also referred to as technology transfer professionals, from four nonprofit research organizations in Missouri. They were noted within their organizations as being extremely successful in transferring innovation from the research and development laboratory to commercial organizations. The population consisted of men and women experienced in the practice of technology transfer, as shown in Table 1. During the course of this study, all project managers or technology transfer professionals working in the four selected nonprofit research organizations were invited to participate in the research; no project manager in the supporting organizations was excluded. The design sought 20 participants for the research; the voluntary response, however, yielded only 10. Although the participants provided a smaller sample size than was planned, the information began to saturate with eight participants, which was likely to occur with a small empirical homogeneous purposive sample (Bernard & Ryan, 2010).

Individual Participants

The sample consisted of 10 project managers, also known as technology transfer professionals, each employed by one of four selected nonprofit research and development organizations in Missouri. The individual participants began their careers in the technology transfer field from multiple starting points. The participants noted three major starting points, consisting of (a) science, (b) business, or (c) law. All but two of the participants began their path to the technology field from a science origin and then acquired either a business background or a law background. All of the participants

expressed the need to have an understanding of science, business, and law, which comprise the three major domains of the technology transfer field. The backgrounds of the participants spanned all three fields. Each participant had a special focus area, generally the primary field that drew him or her to the technology field, and a secondary field, in either business or law. Although all technology transfer professionals knew of and utilized project management practices, none held the Project Management Professional (PMP) certification.

Participating Organizations

The selected organizations are geographically separated in the State of Missouri. The organizations are nonprofit research institutions that support technology transfer activities for a broad range of technology fields. The four nonprofit research organizations are physically located near their supported customers and organizations.

Research Site 1 is a small nonprofit research organization, consisting of three full-time employees in a single team with a broad focus on technology innovation management. The project team is colocated in a central cubical office work area in a facility with a shared work area and meeting room. The project managers have a common reference library with an extensive selection of technology support texts as well as online information references for use by their researchers and developers. The team supports research and technology transfer by identifying and integrating public and private research organizations focused on research and development and on services related to current and future national technology needs (from the organization's website).

Research Site 2 is a small organization with five full-time employees in a single team, with a general focus on managing technology innovations developed by their

organization. The project managers are colocated in a central office work area, physically located in separate offices with a common hallway. The project managers have a common reference library with an extensive selection of technology support texts as well as online information references for inventors. The reference library provides information on research milestones as well as general planning considerations to help guide the inventors and project managers through technology transfer activities. The small team employs the *cradle-to-grave* approach, which means the team manages the complete process of the technology innovations from the beginning (disclosure) to licensing or contract negotiation. Research Site 2 focuses on assisting researchers who are engaged in technology research and development, to help them understand and navigate the technology process (stated on the organization's website). The key technology transfer activities conducted by Research Site 2 are innovation management and entrepreneur support (stated on the organization's website).

Research Site 3 is a medium-sized organization with 16 full-time employees who are organized into three teams. Most of the project managers are colocated in a central office work area, physically located in separate offices. One project manager is located in an off-site office near Research Site 3. The project managers have personal reference libraries with technology support texts as well as information references to help guide the inventors and project managers through the technology transfer process. The general information in the personal reference libraries is similar to the text and online references found in Research Site 2. The three teams manage their technology transfer projects in one of two ways. The first method is the cradle-to-grave approach, similar to Research Site 2. The second method is a *specific focus* on coordinating legal protections while

integrating management actions with members of other areas of their organization. Research Site 3 focuses on identifying and marketing technology developed by their organization (stated on the organization's website). The size of Research Site 3 allows the organization to support a broad range of technology developments while specializing in specific technology fields (stated on the organization's website).

The final organization in the sample is Research Site 4. Research Site 4 is a small organization of five full-time employees in a single team with members who focus on specific areas within the technology transfer process. The project managers are colocated in a central office work area, physically located in separate offices with a common hallway. The project managers have personal reference libraries with a collection of technology support texts as well as information references for their project team members and inventors. The content of the personal reference libraries is similar to that of Research Sites 1 and 2. The small team employs the cradle-to-grave method to manage their technology projects, an approach which is similar to that of Research Sites 1 and 2, the other small nonprofit research organizations in this study. Research Site 4 employs a multidisciplinary research team that focuses on technology transfer and business development (stated on the organization's website).

Table 2
Demographics of the Sample Population

Demographic	Data
Gender	7 men and 3 women
Education Levels	2 participants have a bachelor of science (BS) degree 3 participants have a master of science (MS) degree 5 participants have a doctor of philosophy (PhD), doctor of law (JD), or doctor of law/master of business administration (JD/MBA) degree
Educational Background	5 participants have degrees in science, technology, engineering, or mathematics (STEM) 1 participant has STEM and Business degrees 1 participant has STEM and Law degrees 1 participant has Business and Law degrees 1 participant has STEM, Business, and Law degrees 1 participant has a degree in Public Administration
Credentials	2 participants hold a Patent Bar 2 participants are Certified Licensing Professionals (CLPs) 1 participant is both a Professional Engineer (PE) and a Lean Six–Sigma Green Belt
Average Years of Experience by Organization	Research Site 1–11 years Research Site 2–11 years Research Site 3–17 years Research Site 4–9 years
Professional Technology Organizations	2 participants are members of AUTM (Association of University Technology Managers) and LES (Licensing Executive Society) 3 participants are members of AUTM
Project Management Experience	All 10 of the participants had some project management experience and use project management processes and tools, even though 0 of the 10 have the Project Management Professional (PMP) credential.

Note. This table reflects the demographic data collected from 10 participants using the semi-structured interview and biographical data as shown in Appendix B as multiple sources of information (Yin, 2014).

Thematic Analysis Applied to Data

There are multiple qualitative approaches used for data analysis. The thematic analysis applied to the data used the *word frequency* approach. Bernard and Ryan (2010) highlighted eight observational techniques and four manipulating techniques used to analyze qualitative data. This analysis used one of the observational techniques known as *repetition*, also known as *pattern matching*, which focuses on the number of times a key idea is repeated in the text (Bernard & Ryan, 2010; Yin, 2014). The analysis also used a manipulative technique known as *key-words-in-context (KWIC)* which focuses on the number of unique words used in the content to identify core ideas (Bernard & Ryan, 2010). The word frequency tool in NVivo 11 blends the observational technique of repetition and KWIC, and provides an analysis of the number of times a specific word appears within a specific database (QSR International, 2016b). The word frequency tool in NVivo 11 was applied to the interviews, biographical information, observations, research memos, and research notes. NVivo 11 provided multiple displays of the results of word frequency. The first display of the word frequency results is in the form of a *word cloud*, which visually displays 25 words that most frequently appeared in the database. In the word cloud, the word font-size corresponds to frequency: the larger the font, the more frequently the word appeared in the database (QSR International, 2016b). The analysis of the 25 most frequently occurring words, using the NVivo 11 word frequency tool, is displayed in Figure 8 (QSR International, 2016b).

Figure 8. Technology transfer competencies word cloud. This figure is a word cloud of the 25 words that appear most frequently from the database using the word frequency tool in the NVivo 11 software (QSR International, 2016b).

The second display of the word frequency results is in the form of a *word count summary*. The word count summary provides a detailed count of the number of times the word appeared from the database (QSR International, 2016b). A complementary result of the 25 most frequent words appearing in the database is listed in Table 3.

Table 3
Results of the Application of Word Frequency Tool to Data

Word	Frequency
Technology	128
Business	120
Research	111
Patent	104
Managing	87
Marketing	87
Understand	83
Licensing	75
Development	68
Science	59
Project	57
Process	53
Transfer	49
Skills	45
People	42
Intellectual	39
Engineers	39
Property	37
Knowledge	37
Agreements	35
Commercializing	33
Communication	33
Organized	33
Companies	31
University	28

Note. This table lists 25 words that appear most frequently from the database (QSR International, 2016b).

Data and Analysis Results

This study focused on exploring experiences and perceptions of the competencies needed to be a successful project manager in technology transfer practices in a nonprofit research organization. The interview questions were designed to understand project managers' perceptions and experiences within the social context of their technology

transfer and project management community (Gephart, 1999; Marshall & Rossman, 2011; Lincoln, Lynham, & Guba, 2011). Specific questions were designed to develop an understanding of the (a) personal, (b) knowledge, (c) performance, (d) organizational, and (e) technology transfer competencies necessary for a project manager to be successful in conducting technology transfer activities. The data presented is consistent with thematic analysis framed within the theoretical foundation of expert performance (Ericsson, 2008; Yin, 2014).

Competency Theme Perspectives

This section provides the central themes obtained from the analysis of the data for the necessary competencies of project managers who perform technology transfer activities in nonprofit research organizations leveraging the *KWIC* qualitative manipulative techniques (Bernard & Ryan, 2010). This section highlights five competency areas consisting of (a) personal, (b) knowledge, (c) performance, (d) technology transfer, and (e) organization. The data drawn from the interviews, observations, and biographical information are interpreted into a central theme and summarized for each competency area highlighted in the study. A summary of the competency perspectives is shown in Table 4 and a biographical summary of participants is provided in Table 5.

Table 4
Competency Themes Drawn from the Technology Transfer Program Managers' Data

Competency	Description
Personal Communicating Learning Managing Effectiveness	An ability to communicate clearly the technology project objectives, learn quickly, and manage the project team through the technology transfer process.
Knowledge Research & Development Contracting Processes	An understanding of the research & development process and legal tools supporting technology transfer that are needed to prepare the technology for commercialization
Performance Organized Multi-task Team building	An ability to plan, prepare, and monitor the activities of a team to meet milestones established in the schedule to meeting project objectives.
Organizational Coordinate Processes	An ability to anticipate challenges within the technology transfer process that affect the organization.
Technology Transfer Licensing Patents Intellectual Property Business Planning R&D Funding and Venture Capital Entrepreneurship Marketing	Having established skills for determining key aspects of the technology transfer process specifically focused on understanding and shaping market penetration activities for the technology product and shaping potential follow-on business activities.

Note. This table consolidates the themes drawn from the research data on technology transfer competencies in nonprofit research organizations and adds additional depth to the competencies outlined by Guay (2006) as well as Rasor and Heller (2006).

Table 5
Biographical Summary of the Participants

Participants	Research Site	Years with Organization	Education	Years of Technology Experience
P1	Site 1	8	BS Science MS Public Administration	11
P2	Site 2	11	BS Business Patent Bar JD/MBA	11
P3	Site 2	5	MS Information Science & Technology MA Business MA Law	11
P4	Site 3	13	BS & MS Agronomy	17
P5	Site 3	6	BS Chemical Engineering Patent Bar & MBA JD	11
P6	Site 3	4	BS Microbiology PhD Cell Biology	11
P7	Site 3	6	BS Biology MBA PhD Cellular & Molecular Biology	30
P8	Site 4	4	BA Biology	11
P9	Site 4	3	BS, MS, & PhD Biological Engineering	9
P10	Site 4	4	BS Mechanical Engineering Professional Engineer (PE) Six Sigma	6

Note. This table provides biographical summary of each individual participant, which highlights their years of experience in the technology transfer field as well as their educational background.

Personal

The first competency area focused on personal qualities needed to practice technology transfer as a project manager in the nonprofit research organization. The central theme for the personal qualities, as noted by multiple participants (P1, P3, P7, P8, and P10), is the ability to see the big picture from the perspective of the parties involved in the innovation, their goals, and the application of the technology to a market segment. Another personal aspect noted by multiple participants (P1, P3, P8, and P9) is an understanding of how to provide capital for future development. Funding is one of three major phases in the technology transfer process (Speser, 2006). A large majority of the participants noted that having or developing the ability to communicate effectively in both oral and written form with inventors, business people, and legal representatives is a fundamental personal attribute needed to *translate* requirements in the project management and technology transfer practice. Another focus area among the personal qualities is the ability to learn quickly, solve problems, be a good manager, and stay organized. Interpersonal and social skills are critical in maintaining relationships. The personal qualities also help frame the knowledge competencies needed in the technology transfer communities.

Knowledge

The second competency area focused on knowledge areas needed to practice technology transfer as a project manager in the nonprofit research organization. A majority of the participants (P2, P3, P5, P6, and P7) noted the importance of having an understanding in science, business, and law. Nearly all of the participants noted the importance of having a background in science to help with understanding the research

and the technical information underlying the invention. Within the business area, all of the participants noted the importance of understanding marketing agreements. A majority of the participants noted that having an understanding of licensing, intellectual property, contract agreements, and the patenting process are important components of the legal knowledge needed by project managers and technology transfer professionals. Resoundingly, all the participants noted that project managers and technology transfer professionals need to have an understanding of all three areas: law, business, and science.

Performance

The third competency area focused on performance characteristics needed to practice technology transfer as a project manager in the nonprofit research organization. A large majority of participants noted the importance of being organized and managing multiple projects to meet commercialization objectives while protecting the technology through licensing and intellectual property agreements. Likewise, understanding and developing people skills and team-building provide the foundation necessary to accomplish project requirements. The ability to work well with people, as noted by a majority of the participants, helps in developing an effective organization.

Organization

The fourth competency area focused on organization information needed to practice technology transfer as a project manager in the nonprofit research organization. The ability to bring together and coordinate experts to support a project, similar to an orchestra conductor (P1), and harness their capabilities (P5) to meet the commercialization objectives of the project, is fundamental to organizational competencies. Another important aspect of organization competency is knowing the

stages and processes of technology commercialization, such as (a) pre-disclosure; (b) patent process, both domestic and foreign; (c) marketing; and (d) licensing. Lastly, team learning helps with the sharing of best practices in technology transfer.

Technology Transfer

The fifth competency area focused on technology transfer competencies specifically related to technical knowledge and processes needed to perform the project manager duties involved in transferring technology to commercialization. The knowledge and skills include but are not limited to (a) determining key aspects of the technology transfer process that are specifically focused on understanding and shaping market penetration activities for the technology product, and (b) shaping potential follow-on business activities (Guay, 2006; Rasor & Heller, 2006).

Lessons Learned

The purpose of this research was to explore the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations. Project managers, also known as technology transfer professionals, from four organizations participated in research interviews during which they provided their experiences and perspectives on technology transfer competencies. In addition, observations as well as biographical data from each participant were collected to add depth to the research analysis. The general competency themes from the participants indicated that the technology transfer community draws knowledge from three major fields consisting of science, business, and law. Project managers or technology transfer professionals enter the technology transfer field from

one of these three major fields, either directly or indirectly, and must acquire the competencies from the other two fields to be successful. The participants in this study noted that there was no academic program that led them to the technology transfer field. Most participants began in the science field, merged into business activities, and then learned the necessary legal aspects in order to function in the technology transfer field. Others started in law, merged with business activities, and learned the necessary science to function in the field.

The participants understand the diverse beginnings of practitioners in the field, build upon their strengths, and improve weaknesses in their backgrounds when developing strong technology transfer project teams. The participants did express an expectation that project managers entering the field will build on their strongest field, in most cases science, and quickly learn the remaining two fields, business and law; for example, a project manager with a mechanical engineering degree needs to quickly understand the business aspects of technology transfer and understand the legal requirements soon thereafter. Professional organizations such as AUTM provide self-guided study programs on specific aspects of technology transfer (Association of University Technology Managers, 2016b). Acquiring special credentials in technology transfer, such as the Certified Licensing Professional offered by the Licensing Executive Committee, represent other opportunities for self-development (Licensing Executive Society, 2016b). Although not a specific credential held by the participants, noted as important components in the technology transfer process are project management processes such as (a) initiating, (b) planning, (c) monitoring and controlling, (d) executing, and (e) closing (Project Management Institute, 2013).

Summary

This chapter discussed the findings of the study, experiences and perceptions as described by the participants in their social setting. The participants provided information on their background, specifically how they entered the field of technology transfer and became project managers. The participants provided their experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations. With the exception of two participants, all participants started with a background in science, engineering, technology, or mathematics, and had extensive research experience within the technology field. The project managers entering the technology transfer field did not enter the field directly; their careers originated in one of three major fields—science, business, or law—and they quickly gained knowledge and experience in the remaining two areas. The primary perspectives of project managers regarding competencies in the technology transfer field indicated a need to (a) have an understanding of science, (b) learn quickly, (c) communicate effectively, (d) be able to multi-task, (e) coordinate the technology transfer process, (f) understand the legal protections and contracting, and finally (g) understand avenues for funding.

The next chapter contains (a) the discussion of the results, (b) implications of the study, (c) the limitations of the study, (d) recommendations for future research, and (e) the conclusion of the research. The next chapter helps tie the research to the literature and charts ways ahead for future research.

CHAPTER 5. DISCUSSION, IMPLICATIONS, RECOMMENDATIONS

Introduction

The purpose of this research was to explore the experiences and perceptions of successful project managers conducting technology transfer activities in nonprofit research organizations. The research question was: *What are the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations?* The researcher interviewed 10 participants from four nonprofit research organizations in Missouri to understand their experiences and perceptions of the necessary competencies for project managers practicing technology transfer. This chapter provides (a) a discussion of the results, (b) implications of the study, (c) limitations, (d) recommendations for further research, and (e) conclusion.

The organizations in this study represented a broad range of nonprofit research perspectives. Three of the four organizations were small teams of fewer than five full-time employees, and one was a medium-sized organization consisting of 16 full-time employees. The technology areas of the four organizations were (a) engineering, (b) biomedical, (c) agriculture, and (d) defense industries. The project managers working in nonprofit research organizations—also known as technology transfer professionals—had a general understanding of science, business, and law. The project managers in this study came to the technology transfer field from different origins. Eight of the 10 participants

began by working in the science field. One of the 10 participants began in the business field, and one in the public administration field. None of the 10 participants pursued an academic program in technology transfer as part of their education; however, most did conduct self-directed study by purchasing technology transfer references, and some participated in courses offered by AUTM, ATTP, or LES to gain necessary knowledge in technology transfer and complementary subjects.

Discussion of the Results

Project managers practicing technology transfer in nonprofit research organizations begin their careers from multiple origins, build expertise based on their strength areas, and develop knowledge and skills in other key areas needed to successfully complete technology transfer projects. Project managers in the technology transfer field require knowledge in technology, business, and law (Rasor & Heller, 2006). The small and medium nonprofit research organizations in this study require that their project managers multi-task and that they have a functional foundation in science, business, and law, which is consistent with Rasor and Heller (2006). Larger nonprofit research organizations have the ability to focus on specific practices in the technology transfer process or to specialize in a specific market segment (Wheaton, 2006). Although the 10 participants entered the technology transfer communities from various origins, they are actively engaged in managing technology transfer activities and expressed common competencies necessary to be a successful project manager in the field. The need for a long-term professional development model for technology transfer project managers in small nonprofit research organizations was expressed multiple times by the participants in the study.

The common backgrounds summarized by the technology transfer project managers in the nonprofit research organization are similar to the desirable backgrounds of technology transfer staff members, as described by Rasor and Heller (2006). Eight of the 10 participants in this study have backgrounds in science or technology, and they continued with self-guided study to gain knowledge in business, law, or both in order to build their expertise in the technology transfer field. Although two of the participants did not have a formal background in science or technology, they did have a good background in business and public administration, which provided the business acumen needed to be successful in the technology transfer field. Ericsson (2006) noted that the development of expertise is domain-specific. Project managers practicing technology transfer activities require a disciplined approach to developing expertise. The participants as well as the literature in this research recommend that new program managers in the technology transfer field have an initial background in science or technology, which will provide a foundation from which to gain further knowledge in business and law.

The average length of experience of the participants, which ranged from 10 to 15 years, provides a good foundation to become familiar with the specific tasks needed to be successful in the field. The individuals within the organizations had an experience base that spanned from six to 30 years. Ericsson (2006) highlighted that the development of expertise takes time; developing the requisite skills, knowledge, and abilities may take as many as 10 years to master. As highlighted by the participants in this study, each of them has gained multiple experiences within the technology transfer field over their timespan.

The common competencies expressed by the technology transfer project managers in the nonprofit research organization are similar to the skills, attributes, and

related experiences noted by Guay (2006) in the *Association of University Technology Managers Technology Transfer Practice Manual*. The competency themes expressed by the participants consisted of personal competencies such as being able to (a) communicate clearly the technology project objectives, (b) learn quickly, and (c) manage the project team through the technology transfer process. Similarly, the knowledge competencies focused on having an understanding of the research and development process and the legal tools supporting technology transfer that are needed to prepare the technology for commercialization. The performance competencies centered on the ability to plan, prepare, and monitor the activities of a team to meet established milestones scheduled to meet project objectives. Organization competencies focused on the ability to anticipate challenges within the technology transfer process that can affect the organization. Lastly, the technology transfer competencies highlighted the need to establish skills in determining key aspects of the technology transfer process that are specifically focused on understanding and shaping market penetration activities for the technology product, as well as shaping potential follow-on business opportunities. Figure 9 provides an overview of the competencies nested within their respective domains of science, business, and law, and underpinned by project management practices.

Competencies needed in the technology transfer field can be reinforced through self-guided study options offered by technology transfer professional organizations such as AUTM, CLP, LES, and PMI. Although the PMP credential was not one of the credentials attained by the participants, all of the participants used some type of project management process or tools in their daily activities. Foundational competencies, such as

licensing and patent application, are supported through credentials specific to the technology transfer field such as CLP and patent law.

While the participants' initial entry into the technology transfer field had multiple starting points and experiences, the competencies they highlighted to support the research question provide an adequate shared framework for necessary competencies of project managers in nonprofit research organizations.

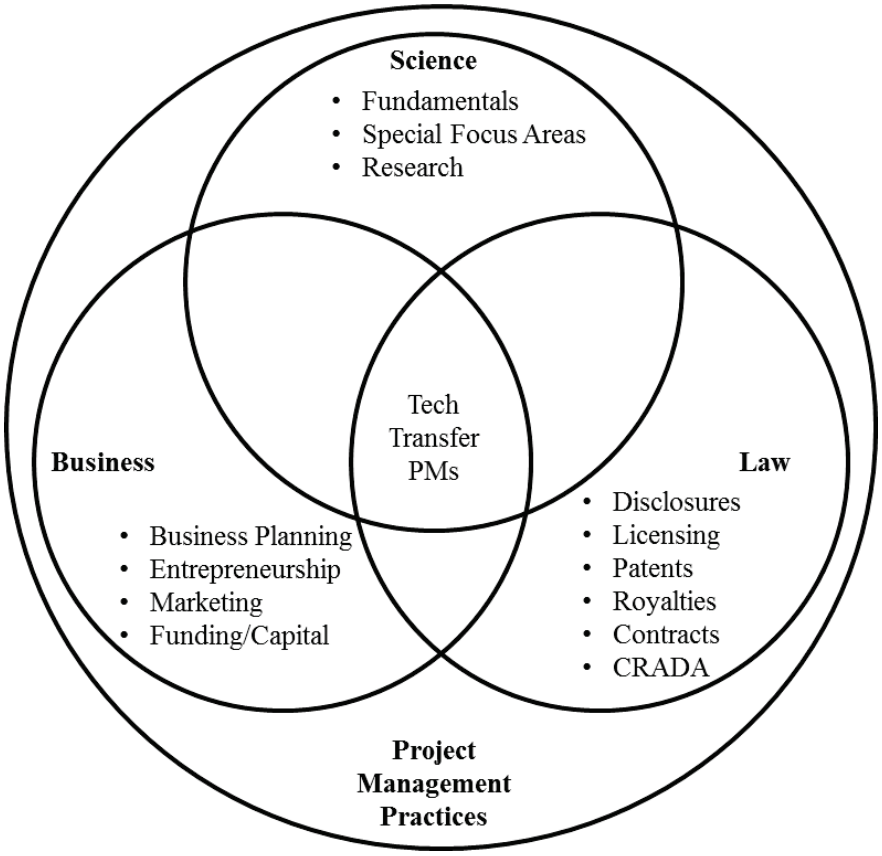

Figure 9. Overview of nested competencies. This figure is an overview of the identified competencies nested within their respective domains of science, business, and law, and underpinned by project management practices that are reinforced by the participants and the literature (Guay, 2006; Rasor & Heller, 2006).

Implications of the Research

This study identified three implications that have an impact on project managers conducting technology transfer activities in nonprofit research organizations. The first is that technology transfer project managers should have an initial background in science or technology, or both. The second is that project managers in small technology transfer teams must have a general knowledge in three areas of technology transfer consisting of science, business, and law. The last implication, based on the data, is that the points of origin for project managers in nonprofit research organizations are generally in science, from which background the project managers quickly acquire knowledge in business and law. As noted by the participants, there is a need to create a professional development model for project managers conducting technology transfer actions in small nonprofit research organization.

Implication 1: Background in Science and or Technology

New project managers or technology transfer professionals entering the field of technology transfer should have a background in the science field for the technology they are managing, or quickly gain a general understanding of the specific science field. For example, the organizational design for one of the research sites has three teams organized with experts who focus on (a) engineering, (b) health science, or (c) life science and agriculture, respectively. The members in each team have science backgrounds that support their focus area. Conversely, the smaller technology teams have backgrounds in science and an understanding of business and law. As noted by the participants, it is important to understand the science, but it is crucial for the technology transfer project

manager to bring special skills beyond those of the inventor of the technology. In many aspects, the inventor of the innovation has devoted multiple years, if not decades, to detailed study in a specific scientific area in order to develop an innovation. The attributes needed by the project manager are to (a) understand the technology management process in the organization, (b) understand the science in order to protect the innovation, if necessary, and (c) reach out to the appropriate market segments, if marketable. Many of the participants noted the need to conduct *prior art* or patent searches, market analysis, and patent searches, referred to by one organization and in the technology transfer community as *triage* (MacWright, 2006). These initial activities start to frame the commercializing potential of the innovation as a fundamental action in the technology transfer process. These aspects are similar to the beneficial skills, attributes, and related experiences outlined by Guay (2006).

Implication 2: Self-Guided Study in Science, Business, and Law

Self-guided study is needed to fill gaps in knowledge in order to manage the technology transfer effectively as a project manager. As noted earlier, in Chapter 4, the competency themes that were highlighted from the data focused on the (a) personal, (b) knowledge, (c) performance, (d) organizational, and (e) technology transfer attributes needed to manage technology transfer innovation. The participants also noted the importance of having a background in or an understanding of science, business, and law; this is reinforced by Rasor and Heller (2006). No formal academic program supported any participant's initial entry into the technology transfer field. Conversely, other professions, such as civil engineering, have formal academic programs through which newcomers can enter the profession, as well as continuing education requirements for

retaining certifications and licenses (American Society of Civil Engineers, 2008). There are self-guided study programs offered through professional organizations that support the technology transfer community. Professional organizations such as AUTM provide self-guided study programs on specific aspects of technology transfer (Association of University Technology Managers, 2016b). Other opportunities for self-development include acquiring special credentials in technology transfer, such as the Certified Licensing Professional offered by the Licensing Executive Committee (Licensing Executive Society, 2016b). As noted earlier, none of the participants held a PMP certification, but all used, on a daily basis, multiple processes and tools from the project management community of practice to help manage aspects of the technology transfer activities.

Implication 3: Professional Development Model for Technology Transfer Project Managers

The third implication of this study is the development of a professional development model for technology transfer project managers in small nonprofit research organizations. A majority of the participants noted a desire to have a developmental model to help guide them in improving their personal performance in supporting their customers. The model provided in Figure 10 is a concept framed around the information gathered from the literature review, specifically supported by the skills, attributes, and related experiences needed by technology transfer professionals, as outlined by Guay (2006) and reinforced by Rasor and Heller (2006). The model also incorporates professional and personal competencies and characteristics highlighted by PMI, ATD, and the ASCE, as well as AUTM. The specific technology transfer credentials

recommended in the field are provided through technology transfer professional organizations.

Background	Entrance to 3 Years	3-5 Years	5-10 Years	10 Years (+)
Science	Education focus: • Business • Intellectual Property Law Certification(s): • RTTP Level I • PMI-CAPM	Education focus: • Business • Intellectual Property Law Certification(s): • RTTP Level II • CLP • PMI-PMP	Education focus: • MBA Certification(s): • RTTP Level III • CLP • PMI-PgMP	Education focus: • PhD-STEM Certification(s): • RTTP Level III • PMI-PfMP
Business	Education focus: • Science • Intellectual Property Law Certification(s): • RTTP Level I • PMI-CAPM	Education focus: • Science (STEM) • Intellectual Property Law Certification(s): • RTTP Level II • CLP • PMI-PMP	Education focus: • MBA Certification(s): • RTTP Level III • CLP • PMI-PgMP	Education focus: • DBA Certification(s): • RTTP Level III • PMI-PfMP
Law	Education focus: • Science • Business Certification(s): • RTTP Level I • PMI-CAPM	Education focus: • Business • Intellectual Property Law Certification(s): • RTTP Level II • CLP • PMI-PMP	Education focus: • MBA Certification(s): • RTTP Level III • CLP • PMI-PgMP	Education focus: • JD Certification(s): • RTTP Level III • PMI-PfMP
Professional Organizations	• AUTM • ATTP • PMI	• AUTM • ATTP • CLP • PMI	• AUTM • ATTP • CLP • PMI	• AUTM • ATTP • LES • CLP • PMI

Figure 10. Proposed career development model. This figure is a proposed career-development model that supports professional development for project managers in small nonprofit research organizations in Missouri. The map is a synthesis of developmental models found in the literature review and competencies highlighted by the participants in the research (American Society of Civil Engineers, 2008; Association for Talent Development, 2016; Association of University Technology Managers, 2006; Project Management Institute, 2007).

The development model in Figure 10 provides recommended education and credential focus points for a newcomer to the technology transfer field. The model provides pathways based on three possible points of origin for the project managers,

those being science, business, and law. Each pathway provides recommended education-focus areas and levels as well as specific technology transfer credentials recognized and held by participants in this study. The development model is provided as a concept; further discussion and confirmation of the model will be needed to validate the focus points and utility to technology transfer project managers in small nonprofit research organizations.

Limitations

There are three limitations noted from this study. The limitations are (a) case study design, (b) sample size, and (c) time. Limitations are an inherent part of qualitative research, as bounds are established in order to focus the context of the study. Although three key limitations are identified, the data collected and analyzed did provide necessary information to answer the research question: *What are the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations?*

Case study, by design, focuses on a specific phenomenon. As such, Yin (2014), highlighted that case study investigates a current phenomenon in detail within its real-world context. One limitation of this case study, as discussed in Chapter 1 of this dissertation, is that generalizations of the competencies cannot be extended to other nonprofit research organizations outside of the research population (Yin, 2014). Nonprofit research organizations range in size from small, with fewer than five full-time employees, to very large, with over 100 (Rasor & Heller, 2006; Wheaton, 2006). Project managers in smaller nonprofit research organizations need a broader understanding of

technology transfer. Larger organizations have the ability to specialize in select aspects of technology transfer activities (Rasor & Heller, 2006; Wheaton, 2006).

The second limitation is the size of the population, which is not representative of a larger general population (Yin, 2014). The case study was limited by a small sample size of participants; however, additional sources of information such as biographical data, observations, and memos help in adding depth to the data. Bernard and Ryan (2010) highlighted that homogeneous purposive samples are likely to saturate early, which occurred in this study. As a case study, the 10 participants did provide sufficient information to saturate the data and identify five themes for (a) personal, (b) knowledge, (c) performance, (d) organizational, and (e) technology transfer competencies. Having more participants to interview would have added additional data to reinforce the themes; however it would also have taken additional time.

The third limitation of the study was the time needed to (a) coordinate, (b) conduct, (c) transcribe, and (d) analyze the data. The interviews were conducted over a three-month period; however, transcribing the interviews—using Dragon NaturallySpeaking, an audio-to-text conversion software—took an additional two months. Due to different dialects of the participants, the automated-transcription error rate increased; as a result, multiple hours were needed to review the audio tapes in order to develop high-quality and accurate transcriptions of the interviews. Still more time was needed to coordinate the member checking of the transcripts with each participant to ensure the transcript was an accurate representation of the interview. Confirming the accuracy of the interviews was a critical activity in the study to ensure that the NVivo11 software would generate products based on high-quality data.

There were no surprising outcomes from the research, in that project managers in the technology transfer field were found to have a need for an understanding of science, business, and law. However, the study did provide one surprise in that a formal professional development model for small nonprofit research organizations is needed. The points of origin for project managers in the technology transfer field varied, but generally the participants began with a science background and then gained knowledge in one or both of the remaining technology transfer fields of business and law.

Recommendations for Further Research

There are two recommendations for further research as outcomes of this study. The first recommendation is to interview a larger population that includes project managers in small, medium, and large nonprofit research organizations. The second recommendation is to explore the utility of the professional development–model concept with technology transfer project managers in small nonprofit research organizations. The recommendations should continue to fill the gaps in competencies needed for project managers practicing technology transfer activities.

The first recommendation, to interview a larger population that includes small, medium, and large nonprofit research organizations, would add additional depth to the necessary-competencies knowledge gap. Interviewing a larger population may include participants who have acquired the Project Management Institute's PMP certification in addition to the technology transfer–community credentials of CLP and RTTP. As noted in this study, each of the participants highlighted the use of project management processes and tools; however none of them possess the PMP certification.

The second recommendation is to explore the utility of the professional development–model concept to technology transfer project managers in small nonprofit research organizations. A common topic highlighted from the participants was the need for a professional development model for small nonprofit research organizations. Five of the 10 participants were familiar with self-guided study programs offered by AUTM. The remaining five participants had undertaken unique professional development programs specific to their area of expertise and organization. The professional development activities in these programs focused on the specific competencies unique to that organization and supported the unique organizational goals and objectives. The unique professional development activities consisted of (a) specialized courses, (b) select self-guided study in licensing and patent activities, (c) job-shadowing, and (d) on-the-job training.

The recommendations for further research may provide additional knowledge to the technology transfer community of practice. The knowledge gained may help future project managers in the technology transfer field.

Conclusion

This study focused on four nonprofit research organizations in Missouri, for the purpose of exploring the experiences and perceptions of successful project managers regarding necessary competencies in the technology transfer process for nonprofit research organizations. The researcher leveraged a qualitative multiple-case-study methodology to explore the competencies of project managers in nonprofit research organizations. Crowe et al. (2011) as well as Yin (2014) noted that a case study is a research approach that provides an intense description and analysis of a phenomenon

bound within its real-life context. The phenomenon in this case study is the identification of competencies needed for technology transfer activities used by project managers in nonprofit research organizations as they pursue commercialization of technologies developed in their universities or research institutes.

As noted in this study, technology transfer is a complicated project process that requires highly skilled personnel who understand the technology transfer practice (Rogers et al., 2001; Speser, 2006). The practice of technology transfer requires a broad understanding of project management and business marketing (Speser, 2006). Some technology transfer projects fail due to (a) lack of funding, (b) failure to follow license and patent agreements, and (c) poor project management practices (Agarwal, 2006; Bremer, 2006; Craane, 2006; Hauth, 2006). By exploring the competencies of successful project managers who focus on the practice of technology transfer, this study identified the necessary skills, knowledge, and characteristics to successfully transfer select technology projects to commercialization in nonprofit research organizations in Missouri.

Competencies are an important aspect of shaping successful projects (Project Management Institute, 2013). Competencies are the skills, knowledge, and characteristics that enable success in a job (Ruyle & Orr, 2011; Sanghi, 2007). The researcher has identified, through the literature review and the analyzed data, that project managers conducting technology transfer activities need a background in science, business, and law (Rasor & Heller, 2006). Likewise, the competencies necessary to successfully manage technology transfer projects require attributes in (a) personal, (b) knowledge, (c) performance, (d) organizational, and (e) technology transfer domains (Ericsson, 2008; Guay, 2006).

The outcomes from the research are that project managers in the technology transfer field need to (a) understand the big picture from the perspective of all parties involved in the innovation, (b) understand technology funding, and (c) have the ability to communicate effectively with the inventor, business people, and legal representatives. The ability to manage multiple projects and to work well with people are important competencies. Additionally, project managers need to understand the technology transfer areas consisting of (a) business, (b) research, (c) patents, (d) licensing, (e) intellectual property, and (f) capital development. The study did identify a need for a professional development model for small nonprofit research organizations in Missouri. The professional development–model concept highlighted in this research will need further elaboration and assessment by a technology transfer population larger than that of this study.

This research provided a literature review focused on expert performance and competency models from multiple fields including (a) project management, (b) talent development, and (c) civil engineering. The literature review provided the foundation for analysis. The researcher used NVivo 11, a qualitative analysis program, to identify themes from the data. The primary perspectives of the competencies of project managers in the technology transfer field were to (a) have an understanding of science, (b) learn quickly, (c) communicate effectively, (d) be able to multi-task, (e) coordinate the technology transfer process, (f) understand the legal protections and contracting, and finally (g) understand avenues for funding. This study adds to the body of knowledge in the technology transfer field and is another piece of information to help project managers function more effectively in the complicated project process of technology transfer.

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APPENDIX A. INTERVIEW GUIDE WITH QUESTIONNAIRE

INTERVIEW GUIDE USED DURING DATA COLLECTION

RESEARCH STUDY: EXPLORING THE EXPERIENCES AND PERCEPTIONS OF PROJECT MANAGERS REGARDING TECHNOLOGY TRANSFER PROCESSES

Interview Guide: Case Study

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

Position of the interviewee:

Introductory script:

Good morning,

I appreciate this opportunity to interview you on technology transfer expertise. The purpose of this interview is to explore research and development project manager developmental models that provide the necessary skills to program and integrate technology transfer practices to successfully transition an innovation from the laboratory to a commercial organization for market. As you know from your own experiences, research and development project managers gain many types of experiences over the course of their management career that help them to successfully transition innovation projects (Rogers, Takegami, & Yin, 2001). The experiences help shape their competencies over time enabling them to quickly adapt to new operational environments and successfully complete projects (Project Management Institute, 2007) Practicing key tasks can improve the quality of decisions made by leaders and managers (Ericsson & Charness, 1994). Maintaining the competencies, through deliberately practicing key project management technology transfer tasks, can help maintain the ability to effectively

integrate technology capabilities to support the competitive advantage of nonprofit research institutes. Lack of practice can lead to ineffective integration of resources and reduce business opportunities.

Within the context of developing expertise to integrate resources (personnel, units, funding) I would like to ask the following questions in an effort to help frame potential developmental models.

Interview questions:

1. Now that you are in a research and development project management position, what do you think?
2. Is the research and development project management position what you expected?
3. Are you enjoying working at the nonprofit research institute?
4. What is your highest level of education (MA, MS, and PhD)?
5. What professional certifications do you currently hold (PE, PMP, PgMP)?
6. How many years have you worked as a project manager in research and development?
7. What project management positions did you hold prior to your current management position?
8. What personal skills do you believe lead to being an expert as a research and development project manager?
9. What knowledge areas do you believe lead to being a technology transfer expert as a research and development project manager?
10. What performance skills do you believe lead to being a technology expert as a research and development project manager?
11. What project management knowledge do you believe leads to being a technology transfer expert as a research and development project manager?

12. What organizational knowledge to you believe leads to being a technology transfer expert as a research and development project manager?

Background information on the question design for the interviewer

The interview guide and framework is an adaptation from Patten's (2012) guide and framework. The questions have been modified in order to collect data unique to this research study. The questions focus on the background of the project managers in nonprofit research organizations. As noted by Patten (2012), the initial questions during the semi-structured interview are aimed at establishing a rapport with the interviewee. Questions 1-3 are modeled after the examples framed by Patten. These questions are intended to establish a rapport with the senior military engineer. Questions 4-6 provide necessary demographic about the participants (Patten, 2012). Questions 7-12 are predetermined questions that are open-ended, focused on the central phenomenon in the study, and guide the interview conversation (Creswell, 2013; Patten, 2012; Yin, 2014).

APPENDIX B. OBSERVATION PROTOCOL

OBSERVATION PROTOCOL

RESEARCH STUDY: EXPLORING THE EXPERIENCES AND PERCEPTIONS OF PROJECT MANAGERS REGARDING TECHNOLOGY TRANSFER PROCESSES

Observation type: Spot

Time of observation:

Date:

Place:

Observer:

Participant:

Position of the Participant:

Observation Protocol Background:

The method used to collect observational data for this research will be direct spot observations of project managers conducting technology transfer practices. The purpose is to observe some of the general daily practices project managers conduct in coordinating technology transfer within a 60 minute time period at the participant's workplace. The rationale for selecting direct spot observation was the short time frame available to conduct the observation. Direct observations are data collections, which require interaction with the participant(s) and consist of two sub-techniques of *continuous* and *spot* (Bernard & Ryan, 2010). Continuous observation is conducted with a participant or participants over an extended period of time (Bernard & Ryan, 2010). Conversely, spot observations are conducted once, over a short period of time, with a participant or participants. Patton (2002) highlights the value of direct observations, providing the researcher with a better understanding of the context and an openness to discovery, capturing activities that may be overlooked or omitted by participants, and offering the ability to draw on firsthand knowledge during interpretation and analysis. Marshall and Rossman (2011), as well as Yin (2014), note that observation can include multiple senses—hearing, touch, and smell—to add to the data collected from a particular observational location. The observational field note design is an adaptation of the design developed by Marshall and Rossman (2011)

Date: **Time:** **Location:** **Type of Collection:** Observation, Direct-Spot **Organization:**	**Observer Comments**
Text:	
Summary	

Note: Field note design is adapted from the sample field notes displayed by Marshall and Rossman. From *Designing Qualitative Research*, (5th ed.), p.141, by C. Marshall and G. B. Rossman, 2011, Thousand Oaks, CA: Sage. Copyright 2011 by Sage Publications, Inc. Adapted with permission.