TECHNOLOGY TRANSFER PROCESS AT TRIBAL COLLEGES AND UNIVERSITIES: A QUALITATIVE MULTIPLE SITE EXPLORATORY CASE STUDY

by

Steven D. Dupuis

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The Dissertation Committee for Steven Dupuis certifies approval of the following dissertation:

TECHNOLOGY TRANSFER PROCESS AT TRIBAL COLLEGES AND UNIVERSITIES: A QUALITATIVE MULTIPLE SITE EXPLORATORY CASE STUDY

Committee: Ify Diala, Ph.D., Chair

Dorothy Potter, Ph.D., Committee Member

Jodi Menees, Ph.D., Committee Member

Ify Diala

Ify Diala

Dorothy Potter

Dorothy Potter

Jodi L. Menees

Jodi Menees

William C. Beck II

William C. Beck II, PhD
Academic Dean
School of Advanced Studies
University of Phoenix

Date Approved: April 21, 2017

ABSTRACT

The purpose of this qualitative exploratory multiple site case study was to identify the factors that affected technology transfer at the selected Tribal Colleges and Universities (TCUs). The specific problem was the unknown factor or factors that appeared to be inhibiting technology transfer at TCUs. The general problem was the lack of verified evidence that technology transfer was formally occurring at any TCU. The research question was: What are the factors that affect technology transfer at Tribal Colleges and Universities? The study involved interviews with 20 senior level administrators and faculty members, five each from the four selected TCUs, along with a review of archival data and field notes. An NVivo10® data analysis of transcribed interviews coordinated with field notes and archival data revealed five themes: Barriers, Optimism, Technology Transfer Strategy, Lack of knowledge about Technology Transfer, and Institutional Research Capabilities. Under Barriers, several subthemes also emerged, which were: Time Constraints, Lack of Administrative Support, Institutional Research Capabilities, Individual Research Capabilities, Remoteness of Institution, and Institutional Core Mission of Academics. The participants in this study demonstrated an optimistic view of technology transfer and its potential, but detailed a number of barriers that must be overcome if technology transfer is to become institutionalized. The results of this study highlighted the need for TCU leadership to better understand how technology transfer might fit within the mission of their respective institutions.

DEDICATION

I dedicate this dissertation to my wife Polly, as without her support and understanding I would have given up many times along this journey. I would like to also dedicate this to my daughters; Lauren, Payton, and Rylie, as they provided the additional motivation to complete my degree. I also dedicate this study to the administration, faculty, and staff at the Salish Kootenai College, as they too provide inspiration and support in my pursuit of a doctoral degree. And finally, I dedicate this dissertation to my family and friends, as without their support and understanding the journey to complete this educational goal would have been impossible.

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Chapter 1

Introduction

Technology transfer is the act of commercializing research project results through licensing, company spinoffs, or other methods, with private industry partners (Bloom, 2011; Powers & Campbell, 2009). Undergraduate research within the science, technology, engineering, and mathematics (STEM) fields has shown to increase students' awareness of applications of research results (Adedokun, Zhang, Parker, Bessenbacher, Childress, & Burgess, 2012). The purpose of this study was to identify the factors that affected technology transfer at the selected Tribal Colleges and Universities (TCUs). TCUs needed to evaluate and understand the potential effects undergraduate STEM research might have had upon technology transfer. TCUs also needed to understand the effects technology transfer may have upon the institution. Although research and innovation is increasing at TCUs (Corbyn, 2011; National Science Foundation, 2011), there appears to be a lack of understanding and interest in transferring the resulting intellectual property to private industry. According to the Association of University Technology Managers (AUTM) organization, no TCU has reported technology transfer activity in the annual U.S. Licensing Surveys from 1991 - 2010 (Bostrom & Tieckelmann, 2010). The lack of publicized revenue-generating technology transfer agreements within TCUs needed to be further investigated, as it was possible that technology transfer might be occurring at some unpublicized level or in conjunction with another organization.

The ability of institutions of higher education to commercialize research results through collaboration with private industry partners was important. Institutions may be

able to gain reputable and financial rewards by transforming innovative research into commercial collaborations (Perry, 2009). However, according to Burnside and Witkin (2008), there are many barriers preventing collaborative agreements between universities and industry, such as potentially lengthy negotiation processes or cultural differences. Through this multiple site exploratory case study, factors were instrumental in exploring through face-to-face interviews to find out how they might be affecting technology transfer. Some of the factors explored were undergraduate research and the increase of PhD level professors at the selected TCUs.

A qualitative multiple site exploratory case study involving four TCUs was conducted to seek insight into technology transfer and what factors were affecting this process. According to Khalozaheh, Kazemi, Movahedi, and Jandaghi (2011), industry often attempts to seek competitive advantage by looking to universities for innovative research results that might have significant commercial implications. Large research institutions have pursued extravagant methods to enhance technology transfer. Such methods included opening large technology transfer offices (TTO) and developing technology parks (Lipinski, Minutolo, & Crothers, 2008). This study constituted an avenue to seek and explore any evidence of TTOs and technology parks in and around the four TCU sites.

Background of the Problem

The creation of the American Indian Higher Education Consortium (AIHEC) in 1972 by the first six TCUs was a significant step toward establishing credibility in the research and education fields (AIHEC, 2012). By 1980 there were 17 TCUs in eight states, each with a mission to expand research and education opportunities for the benefit

of Native American students (O'Donnell, 1992). In 2012, AIHEC membership included 37 TCUs in the United States, and one in Canada (AIHEC, 2012). Therefore, the creation of AIHEC includes purposes that might be derivatives of goals and objectives within the formation charter of the entity as well as the formation charters of the individual institutions making up the consortium in regard to technology transfer.

The amount of research funding has increased slowly for TCUs since 1991 (National Science Foundation, 2011). Research capacity improvements show evidence that innovation has increased within the nation's TCUs (Corbyn, 2011). The number of STEM programs also increased over a 10-year period, as did the number of faculty members with a Master's degree or PhD (AIHEC AIMS Fact Book, 2012). Despite this growth, evidence suggests that the intellectual property that TCUs produced, which might have commercial implications or other economic benefits, appeared to be underutilized (Powers & Campbell, 2009; Heher, 2005). Whether or not benefits accrued to any establishments or communities, being able to convert the inertia within the transfer of technology had the capability to provide a positive impact.

The majority of TCUs are located within remote Indian Reservations. In most cases, the TCUs drive the economic development within their communities (Cunningham, Merisotis, O'Brien, Gonzales, O'Brien, Williams, & Gritts, 2000). Because the purpose of this study was to identify the factors that were affecting technology transfer at the selected TCUs, the issue of economic development was relevant to the discussion. According to Fogarty (2007), attention to the local economy by TCUs is a primary concern. Any benefit that a TCU can make to the local community is in the institution's best interest. Although generating revenue from technology transfer

is important, it should not be the primary focus for TCUs. According to Breznitz and Feldman (2012), universities are looking to conduct research projects that link to local community needs in addition to technology transfer possibilities. The relationship between TCU undergraduate research and technology transfer in terms of local economic development is another facet that deserves attention in this study.

Statement of the Problem

The general problem was the lack of verified evidence that technology transfer was formally occurring at any TCU. The growth in the number of STEM degree programs that also included basic research was increasing within several TCUs (AIHEC AIMS Fact Book, 2012). Evidence indicated an increase in the occurrence of technology transfer at similar mainstream institutions (Adedokun et al., 2012; Wayne, 2010); therefore, further exploration of what factors might be affecting technology transfer was needed.

The specific problem was the unknown factors that appeared to be inhibiting technology transfer at TCUs. The number of TCU undergraduate students participating in research projects had increased with time (AIHEC AIMS Fact Book, 2012). The perceptions of administration, faculty, and staff concerning technology transfer were explored at the four TCUs participating in this qualitative multiple site exploratory case study.

A search of literature produced no substantial technology transfer activity within the TCU communities. One periodical, the Tribal College Journal, has had several articles over the years that mention technology transfer as either a goal for some TCUs or as part of their economic development plan for their surrounding communities. Up to the

time of this research, however, no detailed technology transfer activity had been published. The earliest article mentioned technology transfer as part of a collaboration on a forest research center between the College of Menominee Nation and the U.S. Department of Agriculture (Anonymous, 2004). The last article to bring up technology transfer was by Benton (2012), which stated TCUs technology transfer was demonstrated through new technologies, and the information that was shared through a clearinghouse. Therefore, further investigation was needed to determine what technology transfer was occurring within the selected TCUs for the qualitative multiple site case study.

Tribal colleges and universities are a relatively new class of higher education institution, with the first TCU coming into existence in 1968 (AIHEC, 2012). The main purpose of establishing a TCU was to meet the needs of Native American students (AIHEC, 2012). Again, with the gap in literature pertaining to technology transfer and TCUs, further research was needed to determine the level of technology transfer at the TCUs that participated in this study. Wahab, Rose, and Wati-Osman (2012) stated the transfer of technology from laboratories of higher learning institutions to the private sector has had a long history and had taken diverse forms. Lipinski, Minutolo, and Crothers (2008) noted university-industry partnerships in science and technology faced complex issues that included publication of research results, information exchange, intellectual property protection, and contractual agreements. Tribal colleges and universities, which in most cases are chartered by their respective tribal governments, are a unique group of higher education institutions that might be affected by these complex technology transfer issues (AIHEC, 2012). This qualitative multiple site exploratory case

study of the four selected TCUs involved investigating how these issues affected technology transfer.

Purpose of the Study

The purpose of this qualitative exploratory multiple site case study was to identify the factors that were affecting technology transfer at the selected TCUs. TCUs need to evaluate and understand the potential impacts undergraduate STEM research may have upon technology transfer. TCUs also need to understand the effects technology transfer might have had upon the institution. Four TCUs were part of the qualitative exploratory multiple site case study. Participant responses to interview questions helped to determine and reveal the unknown factors that might have affected technology transfer within the TCU institutions. In addition, to provide a high level of validity and reliability within the study, archival data and field notes were used to triangulate the areas of study.

Exploratory case study design utilizing multiple sites was the most appropriate direction for this study because, according to Neuman (2006) in cases where there is little to no prior research, exploratory case study is the best choice. This selection of research approach is best because the format permits the researcher to gather the opinions of key stakeholders, review archival data, and take note of observations at the multiple TCU locations or sites.

The sample size consisted of 20 individuals among whom were five individuals from each of the four selected TCUs answered interview questions in this exploratory case study. The population for this study comprised of people working in all AIHEC-member TCUs, which included administration, research and academic departments (as instructors). These population eligibility requirements were applied when targeting the

study sample of 20 at the four institutions. The sample within this population included the presidents, vice-presidents, faculty, and researchers who had potentially the most understanding of the factors that might be affecting technology transfer. The multiple site case study method provided perspectives from multiple angles within the topic of technology transfer at TCUs. In addition, the four selected TCUs represented four different geographic areas within the United States. These areas are the Northwest, Southwest, Midwest, and Great Lakes regions.

The institutions and participants in this qualitative exploratory multiple site case study were based upon purposive sampling. The use of purposive sampling is when a certain population is needed because of some characteristic of the study (Marshall & Rossman, 2011). In this study, knowledge about technology transfer, undergraduate research, and institutional culture were the characteristics sought for this study.

The multiple site case study approach facilitates the discussion of ideas and opinions through the interview process rather than group discussion, professional debates, or direct observations that characterize other qualitative study design (Neuman, 2006). Therefore, selected experts for this multiple site case study offered broad perspectives on the topic of technology transfer. The interview format through the qualitative case study approach provided a way to understand better the level of research, organizational leadership, institutional culture, and research capacity at participating TCUs.

Data collection activity involved asking interview participants questions regarding undergraduate research, organizational leadership, and technology transfer activities at their respective TCUs. A review of university archival data, such as annual reports, strategic plans, etc. and field notes helped to triangulate the results of interviewing, thus

bolstering reliability and validity. The data collection instrument contained open-ended style questions. Each participant had the opportunity of responding to the questions revealing their exposure to undergraduate research, organizational leadership, and technology transfer at their colleges. Anderman and Anderman (2009) explained that in-depth open-ended interviews serve useful purposes in providing reliable information about the encounters of research participants.

Significance of the Problem

There has not been a study on technology transfer conducted at TCUs. Exploration into this activity was necessary because technology transfer had been a part of mainstream universities since the Morrill Land Grant Act of 1862 (Duemer, 2007); TCUs appeared to be a long way behind mainstream universities in this area. The level of technology transfer at universities within the United States increased substantially after the passage of the Bayh-Dole Act of 1980 (Dai, Popp, & Bretschneider, 2005; Nilsson, Rickne, & Bengtsson, 2010; Siegel, Veugelers, & Wright, 2007). The lack of information about technology transfer within the TCU community indicated a need for an in-depth study into the factors affecting technology transfer.

Significance of the study to leadership.

Understanding the issues and procedures involved with technology transfer from the perspective of TCU leadership may provide valuable information. This information may provide the incentive for TCU leadership to further explore how technology transfer can benefit not only their institutions but also their community. Therefore, the study is significant to leadership in that TCU faculty and administrators now have more information about what might be affecting technology transfer at their institutions.

Nature of the Study

The use of direct observation was not appropriate because of the lack of evidence that technology transfer was occurring in a formal manner at any TCU. Direct observation is relevant for such areas that involve the viewing of activities or events that are of interest to the research topic (Miles & Huberman, 2013). Therefore, the ideal method for this qualitative exploratory case study utilizing multiple sites was the one-on-one, face-to-face interview technique. Prior to full-scale data collection activities, a field study occurred for the purposes of validating the instrument. The feedback and responses from field studies allow for modification of questionnaires where necessary (Cooper & Schindler, 2008). This field study in this instance involved using volunteers from a TCU in which all but one were not part of the main study.

Research method appropriateness. Research methods include qualitative, quantitative, and mixed methods. Quantitative methods uses statistical examination of quantifiable data to look for deviations from what would be normally expected (Marshall & Rossman, 2011). According to Neuman (2006) quantitative research uses numerical data, and diverse items are quantified in the process of looking for trends. A mixed method study involves the mixing of both qualitative research and quantitative data in a single study (Miles & Huberman, 2013).

A quantitative study approach was not feasible for this study because after a thorough review of the literature, no significant technology transfer was found at any TCU. The use of quantitative research requires the collection of numerical data that is statistically analyzed to identify trends and relationships between variables (Miles & Huberman, 2013). The lack of numerical data is a factor for the use of a mixed methods

design as well. A mixed method study is a good way to gather qualitative data and clarify or support the findings between variables with quantifiable facts (Miles & Huberman, 2013); however this approach was not appropriate for this study.

A quantitative or mixed methods study would not have fully captured the potential issues surrounding the matter of TCU technology transfer. In quantitative study, researchers conduct statistical analysis of quantifiable data and look for anomalies within the facts (Marshall & Rossman, 2011). Conversely, in qualitative research, the qualitative method would serve best in conducting this study because of its features that allow researchers to capture participant personal connection with a problem under review, and researchers focus on the development of themes around a topic (Neuman, 2006). The choice to conduct an exploratory multiple site case study, in this instance, is in direct response to the nature of the problem; multiple sites must be studied in order to form generalizations about the issues surrounding technology transfer in TCUs.

Research design appropriateness. Research designs include case study, ethnography, narrative, grounded theory, phenomenology. Case study design became the choice for this study because it would involve taking closer look at the phenomenon than other designs would offer. Although other designs had the capacity to fit the study, those designs did not have the elements necessary for focusing on just one event or item as much as the case study design did. Pertaining to ethnographic design according to Marshall and Rossman (2011), investigating the lives of people or other mammals in their natural places of abode would require ethnographic design. Thus a researcher may deal personally with the people in their dwelling places over a period long enough to reveal the nuances of their lives and livelihood. Nwosu, Nwosu, and Nwosu (2013) conducted a

study on Diaspora capital flight and brain drain using ethnographic design. That study revealed the conditions of some Africans in the United States in an ethnographic manner. The ethnographic design would not be appropriate for this study on TCUs. Grounded theory design helps a research to explore different avenues to find reasons for the way of life or culture within a studied group(s). In the process of grounded theory, explanations emerge as to why things take the shapes and forms within the studied population (Strauss & Corbin, 1998). Such investigation does not apply to a study on technology transfer and TCUs.

Case study design allows a researcher to focus on a specific issue such as people, group, profession, occupation, organization, problem or situation (Yin, 2012). Technology transfer situations at TCUs were a specific problem, and qualified for a case study design. This is why the case study design was more applicable to this study than other qualitative research designs. Phenomenology is a design that delves into the lived experiences of people (Moustakas, 1994). Open-ended interviews are often necessary for capturing everything a research participant has experienced. This design did not apply to a study on TCUs. A narrative design is a research approach in which a researcher may use all possible avenues of information to gain the understanding necessary to answer the research question(s) (Holstein & Gubrium, 2012). Some of those avenues could be photos, family tree, observations, discussions, personal biographies, and any other items that the researcher identifies as potentially useful in capturing information. Using this design would have removed the study on TCUs from its course. Therefore, it was not appropriate for this study and the exploratory case study was the appropriate design for this study.

A qualitative exploratory case study method utilizing multiple sites was appropriate for this study because the problem of TCU technology transfer required further explanation and establishment of issues affecting technology transfer across several institutions. The research study sample included 20 participants among whom were senior level administrators and research professors at the four selected TCUs. This type of purposeful sampling technique was important because of the specific nature of the study. Because this was the first study of its kind for TCUs, exploratory studies have a tendency to provide future researchers topics with more specific questions in which to seek answers. Qualitative data can be collected in various ways, some of which includes in-depth interviews, direct observation, and case study (Marshall & Rossman, 2011; Neuman, 2006).

Data analysis for this study utilized tools contained within NVivo10®. NVivo10® is a qualitative data analysis package created to help organize and analyze unstructured data (Richards, 2002). Once the data have been collected from interviews the data constituted input in NVivo10® and coded for emerging themes and subthemes. According to Miles and Huberman (2013) after collecting and organizing the data from a research study, the next step should be to condense and code raw data to determine themes.

Units of measurements are rare and often inapplicable in qualitative studies. However, qualitative measurements in this substantive study relied on the frequencies of word use, concept use, and paradigm that occur across all participant responses. These terms, words, concepts, and paradigms helped to reveal the extent to which participants cared about issues associated with those usages. Researcher conducted the analysis

through the necessary keystrokes to input participant responses from the transcripts into the NVivo10® software and ran the analysis. In the process of analysis, researcher looked for the process by which TCUs might have handled the transfer of technology.

The way and manner in which the TCU participants would reveal if there were gender issues, age issues, or other classifications that might have contributed to their approach on the research topic is a consideration. Such considerations may only occur in the process of analysis to warrant categorizations. In order to eliminate bias, researcher avoided stating any preconceived notions on potential findings. Such statements would need participant data and the analysis thereof in order to make conclusive presentations. Furthermore, any number proposed for participants on the multiple research sites may not constitute a predetermination because data collection may go beyond that number. The ultimate basis for data collection termination would be data saturation. This would occur when participant responses, observations, field notes, and university archival files begin to yield a reoccurrence of the same or similar data.

The data presentation was the outcome of the analysis and distillation of the developed themes around technology transfer. Emerging themes enabled researcher to know what factors drew most of the participants' attention, with supporting evidence from archival data and field notes. Further than that, the frequency of each theme revealed the extent to which participant attention to the theme's antecedents might have led to answering the over-arching and secondary research questions. Data triangulation was also used to cross-examine the qualitative aspects of the study. According to Tellis (1997) the ethical need to ensure reliability and validity through triangulation is an integral part of exploratory case study.

Research Questions

The primary focus of this qualitative exploratory case study was to investigate the factors affecting technology transfer at multiple TCUs and identify what might be impacting the procedure. This investigation led to a better understanding of the barriers and potential solutions for TCUs to better conduct technology transfer. Informed stakeholders were involved with an in-depth interview with questions designed to address the following main research question: What are the factors that affect technology transfer at Tribal Colleges and Universities? Secondary research questions addressing the lack of information are as follows:

1. What pieces of information are lacking about technology transfer at TCUs?
2. What are the factors that influence technology transfer at TCUs?
3. How does undergraduate research impact technology transfer at TCUs?

Conceptual Framework

In 1923 Henry Fayol propounded the administrative theory. In 1930, he sharpened it to apply to industrial environment because of his engineering and mining background. In 1949 he released his 14 principles of administrative management, which theory has guided many studies and business operations across the continents (Fayol, 1949). Henri Fayol described five functions of management within his classical management theory. In addition, Schimmoeller (2012) described 14 administrative principles that Henri Fayol also incorporates into his classical management theory. According to Fayol (1949) management must be able to command, organize, control, coordinate, and plan functions within the organization. For a TCU to implement a technology transfer strategy within their organization, a strategic plan encompassing Fayol's functions would be a good start.

The conceptual framework for the qualitative multiple site case study was based upon Henry Fayol's theory of administrative management. Other theorists and scholars had created concepts and conducted studies that relied on Henry Fayol's theory. This theory, the rational and classical management theories, in addition to the works of Peter Drucker (2001) and Schimmoeller (2012) formed good bases for a study on TCU technology transfer process. According to Scott and Davis (2007) rational theory is the collection of personnel, tasks, and the allocation of resources. The classical management theory centers on 14 Administrative Principles (Schimmoeller, 2012) and five management functions (Fayol, 1949). Peter Drucker, who coined the term *knowledge worker*, was a firm believer in management surrounding people (Drucker, 2001). Several concepts were reviewed to support this research study, but these three theories provided the framework.

The rational theory perspective concentrates on the organizational tasks to be performed, the personnel attributes required to perform these tasks, and the allocation of scarce resources to guide organizational decision-making (Scott & Davis, 2007). This theory related to the study because to participate in technology transfer, an institution must understand the tasks involved with technology transfer, the personnel traits required and the investment of scarce resources required for the process.

Definition of Terms

The inductive nature of this case study requires general knowledge of the terms and their definitions for a clear understanding in line with instructions from Tellis (1997). The following terms guided this case study:

American Indian Higher Education Consortium (AIHEC). AIHEC is a political organization established in 1973 to represent the needs of TCUs. Headquartered in Washington, D.C., AIHEC is instrumental in the support of TCUs (AIHEC, 2012).

Association of University Technology Managers (AUTM). AUTM is a non-profit organization with an international membership of more than 3,200 technology management professionals and business executives who handle intellectual property and represent over 300 universities, research institutions, and teaching hospitals, in addition to numerous companies and government organizations (AUTM, 2013).

Basic Research. A process of investigation into certain phenomena that may lead to the development of a new scientific discovery, with a goal of ultimately becoming a marketable product or service (Calvert, 2004).

Indian Reservation. An area of land reserved for a Native American tribe or group of tribes that was established by a treaty with the United States government (AIHEC AIMS Fact Book, 2012).

License. The right to use a product or service that was developed and may have been patented and where a formal agreement that usually involves the payment of royalties to the originator of the product or service (Lin, 2011).

National Science Foundation (NSF). The NSF is an independent agency of the U.S. government created by congressional action in 1950. The Foundation is led by a presidentially appointed director and overseen by a 24-member National Science Board, which is also appointed by the President of the United States. The NSF has a mission to support fundamental scientific and engineering research, in addition to discovering new and innovative ideas for the future (National Science Foundation, 2011).

Technology. The applied application of an innovative product or service in a practical manner (Adner & Snow, 2010).

Technology Transfer (TT). Is a procedure that involves the transfer of new and innovative findings that have resulted from scientific research in one organization to another. The purpose is typically to either further develop the product or service, or move it out to the commercial marketplace. In addition, agreements are made among the parties through licensing, partnering, selling, or spinning off a new organization (AUTM, 2013).

Technology Transfer Office (TTO). A department dedicated to securing patents, pursuing licensing agreements, and other technology transfer processes within a university (AUTM, 2013).

Tribal Colleges and Universities (TCUs). A unique institution of higher learning chartered by a federally recognized Indian tribe of the United States (AIHEC, 2012).

Assumptions

In this study, the participants had to acknowledge the terms and conditions of the qualitative case study. Therefore, it was assumed that the study participants from each site understood the confidentiality and anonymity about the research study. They were required to respond with honest answers. Also, it was assumed that all volunteers in the study would be available at their respective interview times.

There was an assumption that the leaders, researchers, and instructors at the participating TCUs understood technology transfer. It was also assumed that all study participants would have an understanding of undergraduate research. Furthermore, it was assumed that the chosen group would be representative of the population as a whole.

Scope and Limitations

The scope of the study involved participants from four different TCUs in four different states across the United States. This approach provided a good cross section of participants. The areas covered by the four different TCUs included the Rocky Mountains, High Plains, Midwest Woodlands, and Desert Southwest regions. In addition, several distinct tribal nations were presented in the study.

The multiple site case study on the issues pertaining to technology transfer at TCUs had various limitations. The first limitation was the dependence upon the study participants to be honest in their interview question responses. The unknown level of understanding about technology transfer and exactly what it entailed might also be a limitation. In addition, a limitation might exist where the field study volunteers were not to be used as part of the main study because of major changes that could have been required. However, due to the need for only slight modifications to two questions, one TCU volunteer survey was used as part of the main study.

Delimitations

The responses of participants who were experts could becloud or possibly help thoughts of others who were not experts and would not participate in this research study. Participants had expertise in TCU issues and were aware of undergraduate research and technology transfer. The study involved four TCUs that had a varying number of students, had STEM programs, and had been in existence for at least 20 years.

Chapter 1 Summary

The issues surrounding technology transfer at TCUs constituted the focus of this qualitative, multiple site case study. The importance of understanding how technology

transfer affected TCUs needed hands-on demonstration. The perceptions upon the possible influences that undergraduate research might have upon technology transfer needed in-depth exploration within the selected TCU participants. The contributions that universities make to their local economies are no different than that of TCUs (Breznitz & Feldman, 2012). Further understanding of TCU contributions might be achieved upon study completion.

The TCUs continue to expand degree program offerings and improve undergraduate research experiences. Therefore, additional avenues of opportunities such as how the role of technology transfer could be expanded needed investigating. Students at TCUs were experiencing better opportunities to conduct research at their local institutions (Zaffos, 2013). Consequently, technology transfer needed to be focus upon within a TCU's research process. The lack of information regarding technology transfer at TCUs required a thorough assessment. Such assessment could facilitate further understanding of the issues such as undergraduate research and possible relationships to technology transfer.

Chapter 2

Review of the Literature

The purpose of this review was to explore the relationship between tribal colleges and universities (TCUs) and technology transfer; specifically, whether or not undergraduate research at TCUs demonstrates any influence upon technology transfer activity. Analysis of existing literature revealed that, while TCUs continue to address problems considered prerequisite to developing technology transfer practices, there are a number of existing barriers preventing them from achieving a solid foundation for technology transfer (Bowman, 2009; Cullinane & Leegwater, 2008; Hawkins, 2011; His Horse is Thunder, 2012; Karlberg, 2007; Murray, 2006; Pekow, 2007; Shah, 2009; Swisher, 2004; Talahongva, 2009; Vance, 2010; Kicking Woman, 2011).

The following review presents a brief introduction and history of TCUs, the role of STEM research and education in TCUs, the status of TCU research as well as several unique obstacles experienced by TCUs. A few models will be highlighted that appear to be significant to the discussion of how technology transfer could more readily occur at TCUs. A review of the cultural significance of TCUs and a more direct approach to the specific issues surrounding technology transfer at these facilities will conclude the review. Technology transfer between mainstream universities and industry has been occurring for a number of years, TCU institutions must find out if opportunities to become involved in this form of economic development could be beneficial in their respective reservations.

Research Documentation

In Chapter 2, a detailed review of articles, university websites, organizational websites, government websites, government reports, dissertations, and journals is presented. In addition, an exhaustive search of EBSCOhost, ProQuest, Gale PowerSearch, Emerald, Sage Full-Text Collections, and Google Scholar was conducted. Over 300 sources were reviewed and of those 68 were cited as sources for Chapter 2.

Defining technology transfer

Technology transfer is the process of moving research project results from higher learning institutions to organizations that have global presence, adequate marketing experience to develop the idea, and real implementation power (AUTM, 2013; Bloom, 2011). Technology transfer appears to have various definitions depending upon the circumstances. For our purposes, technology transfer is a procedure that involves the transfer of new and innovative findings that have resulted from scientific research in one organization to another (AUTM, 2013). The purpose is typically to either further develop the product or service, or move it out to the commercial marketplace. In addition, agreements are made among the parties through licensing, partnering, selling, or spinning off a new organization (AUTM, 2013).

While the transfer of new technology from institutions of higher learning to the private sector has taken diverse forms (Choi, 2009; Nilsson, Rickne, & Bengtsson, 2010) , it has been a part of mainstream colleges and universities since the passage of the Morrill Land Grant Act of 1862 (Brenner & Buckhalt, 2007). Technology transfer was further strengthened by the passage of the Bayh-Dole Act of 1980 (Dai, Popp, & Bretschneider, 2005). The Bayh-Dole Act of 1980, allowed universities to keep patent

rights and invention licenses developed through federally funded research projects (Colaianni & Cook-Deegan, 2009). Technology transfer after the Bayh-Dole Act significantly increased for universities (Dai, et al., 2005).

Technology transfer is an extremely difficult process to undertake. There are a number of reasons technology transfers can collapse; some universities design extremely complex systems that make it difficult to reach licensing agreements while others have created barriers between academia and technology transfer which have a tendency to eliminate faculty incentive (Dai et al., 2005). Problems can arise during the planning stage if the transferee's needs are not met or if they have overestimated their technical capabilities (Lipinski, Minutolo, & Crothers, 2008). Lack of committed management, differences in working methods between transferor and transferee, the shrinking of local markets, poor physical infrastructure and inadequate institutional support can also derail a project (Lipinski et al., 2008). Other issues can arise if the wrong technology is selected to be transferred, if it is to complex or too expensive to develop, if the technology needs too much adaptation to suit local conditions, or if it becomes obsolete during the transference process (Lipinski et al., 2008; Markman et al., 2008; Powers & Campbell, 2009).

Tribal colleges and universities (TCU), which are chartered by their respective tribal governments (AIHEC, 2012), have historically experienced additional technology transfer related difficulties such as the lack of research publications, the complications around acquisition of contractual agreements, and the protection of intellectual property licenses (Crazy Bull, 2004; Davis et al., 2007; Faircloth & Tippeconnic, 2004; Hernandez, 2004).

History of the tribal college and university (TCU)

The first tribal colleges and universities (TCU) were established following the American Indian 'self-determination' movement of the late 60s, which advocated for provision of post-secondary education that would strengthen reservations as well as tribal culture without assimilation (Chandler, 2010). Prior to this time education was passed on through ways of knowing and storytelling from elders to younger members of the community (Pewewardy, 2002). TCUs were set up with an aim of increasing access to higher education for youth living on reservations while providing basic education to first-generation Native college students (AIHEC, 2012; Kicking Woman, 2011; Swisher, 2004; Talahongva, 2009). The first tribal college to open was Diné College in 1968 (AIHEC, 2012; Talahongva, 2009). Thereafter, other tribal colleges (primarily two-year affiliates to mainstream universities) opened in South Dakota, North Dakota, Montana, and California (AIHEC, 2012). By the 1980's 20 TCUs had been established and by 2010 there were 36 TCUs in 14 states (Chandler, 2010; AIHEC, 2012). While most TCUs have kept their two-year offering, several now offer four-year degrees and two TCUs support post graduate education (Talahongva, 2009).

One of the long-term problems that TCUs have addressed is the legacy of schooling for American Indians. Education for American Indians has historically occurred through assimilation and usually involved uprooting students from reservations and moving them to boarding schools so as to educate them in American ways (His Horse is Thunder, 2012). While the curriculum at TCUs focuses upon English literature, mathematics, science, and technology, the a prime objective of TCUs is to provide higher education for Native American students without compelling them to adopt mainstream

white culture while away from familiar surroundings (Chandler, 2010; Talahongva, 2009). Therefore, programs at TCUs must be tailored to address the double mission of meeting national and state standards while also preserving native culture (AIHEC AIMS Fact Book, 2012).

Initially, scientific research was not as prevalent at TCU's because the institutions sought to promote tribal culture and local economic development (AIHEC, 2012). Thus, education focus was on vocational training programs and classes were frequently taught by tribal elders and other non-traditional faculty members (Talahongva, 2009; AIHEC, 2012). Priority was placed on growing the institution and increasing their historically low enrollment, not on building or conducting technology transfer. However, the Bayh-Dole Act has had an influence introducing and promoting the concept of technology transfer, such as the partnership with the United States Department of Agriculture and the College of the Menominee Nation (Anonymous, 2004). Although no evidence of technology transfer can be found relating to this partnership, the framework appears to have been established and some TCUs have become centers of research and keepers of knowledge (AIHEC, 2012; AIHEC AIMS Fact Book, 2012).

Research and innovation have been increasing in TCUs, however, intellectual property that could have commercial application and economic benefit through technology transfer has been underutilized (Powers & Campbell, 2009). The transfer of technology could bring financial support to TCUs and may provide local job opportunities for graduates who want to remain in the communities after graduation (His Horse is Thunder, 2012). Therefore, partnerships between TCUs and local businesses are an integral part of commercializing university-generated inventions at higher education

institutions (Powers & Campbell, 2009). The National Science Foundation continually seeks to create programs in hopes of creating technology transfer partnerships involving TCU institutions (National Science Foundation, 2011; MtEPSCoR, 2012), as local economic development is continually in need of support (Fogarty, 2007).

The role of science, technology, engineering, and mathematics (STEM) in TCUs

Science, Technology, Engineering, and Mathematics, often abbreviated to STEM, has become a major focus for the United States in the educational, governmental, and private sectors due to the high demand for qualified American citizens with college degrees within these fields (Holdren & Lander, 2012). Diversity among the STEM workforce is a major focus of government agencies, such as the National Science Foundation (National Science Foundation, 2011). Because TCUs are adding bachelor degree programs in the STEM fields that are part of the national focus, Native American students have seen a greater opportunity to conduct high level research within their home institutions (Zaffos, 2013). With this increase in STEM research and education, a greater opportunity to participate in technology transfer exists.

TCU programs, such as the Model Institutions for Excellence (MIE) program, developed in conjunction with the National Science Foundation, have increased participation levels among Native Americans in STEM fields, which historically had much lower rates of native participation and graduation than primarily white colleges (Cullinane & Leegwater, 2008). As evidence of the benefits brought about by this type of collaboration, the MIE project involved a number of TCUs and showed promising results in STEM participation (Kee & Merisotis, 2007). The Navajo Technical College (NTC) improved its STEM field education by combining active research and service

learning methodologies (AIHEC AIMS Fact Book, 2012). Partnerships in STEM fields were also established with high schools in the Navajo Nation in efforts to increase interest in these fields at an earlier age. A four-year program in native environmental sciences was recently launched at Northwest Indian College (NWIC) (AIHEC AIMS Fact Book, 2012). The MIE program has improved select TCUs STEM participation and graduation rates, while still acknowledging the need to remain relevant to culture and community in the world of professional standards.

In another effort to further advance the science and technology fields, Montana initiated the NSF funded, Montana Experimental Program to Stimulate Competitive Research (MtEPSCoR) to address a host of issues from workforce development to cyberinfrastructure (MtEPSCoR, 2012). Goals of the MtEPSCoR program included hiring additional faculty specializing in necessary scientific areas, investing in research facilities, and building an outreach program under a statewide umbrella institute called the Montana University System (MtEPSCoR, 2012). Because the number of Native American researchers in the STEM fields is low, the program targets more diverse additions to faculty (MtEPSCoR, 2012). Therefore, the MtEPSCoR has pursued increasing STEM discipline success for Native American students by providing accelerated math preparation for pre-college Native American high school students, and offering scholarships through the Native American Research Laboratory at the University of Montana. The overall goal is to increase the number of Native Americans completing degrees in STEM fields which will then lead to more college level Native American students in environmental science. MtEPSCoR (2012) has facilitated a comprehensive statewide program for developing the STEM infrastructure in the state of Montana. The

very existence of this project highlights the need for more Native faculty and increased STEM participation by students at TCUs. Growth in both of these areas is necessary for participation in technology transfer.

TCU research in a Western world

Research conducted at TCUs is done in a manner that is fundamentally different from research at traditional colleges and universities and creates tensions for TCUs when attempting to bridge the worlds of mainstream America life and tribal life (Bowman, 2009). Taught first by elders, native science goes beyond objective measurement, and values direct experience, interconnectedness, relationship, and holism (Davis et al., 2007). It focuses on systems of relationships and their application to the life of the community; it transcends division of applications into departmental specialties (Davis et al., 2007). Native science is rooted in ecological theory, and believes in the harmony of the universe (Davis et al., 2007). The primary methods of native science are observation, experiment, understanding one's responsibilities to the entities of nature, objectivity grounded in subjectivity, and unity (Faircloth & Tippeconnic, 2004).

Native science is also communicated through highly representational and contextual models in which information is conveyed on many levels, all to elicit higher order thinking (Davis et al., 2007). With regard to causality, native science believes in causes that go beyond physical principles and involve synchronicity and the action of natural energies (Faircloth & Tippeconnic, 2004). Through meditation and reflection the mind, body, and spirit interact via dreams and visions; in this way the person is fashioned into the primary instrument of coming to know (Davis et al., 2007). In native science, everything in life is believed to have a spirit; meaning of findings are based entirely on

context, and individuals develop their explanation for things based on a multiplicity of metaphoric stories, symbols, and images (Davis et al., 2007). The authority of native science is gained through direct experience, dream or vision, the sanctity of a relationship developed with the environment over time, or through tribal elders (Faircloth & Tippeconnic, 2004). Native science believes the earth is sacred and values locations as having special energy (Davis et al., 2007). Over time, native science has predetermined systematic activities of learning, based on inherent patterns of trajectories, to guide the quest for knowledge, meaning, and understandings (Faircloth & Tippeconnic, 2004). These activities have been variously called the Good Red Road, Dream Time Path, Earth Walk, and Pipeway (Davis et al., 2007).

More pointedly to technology transfer, the application of technology in native science is based on intrinsic need and done so with caution in order to protect social values (Faircloth & Tippeconnic, 2004). Native science believes that one lives well through maintaining harmony with the universe, if a potential technology disrupts this it will not be developed (Davis et al., 2007). This description of views about technology would seem to suggest that native science is an inherent constraint against technology transfer acceleration at TCUs. At the same time, humans have special responsibilities to the natural world and other livings things as they facilitate knowledge through conscious thinking and tool making. According to Faircloth and Tippeconnic (2004), while native science is based on deep ecology, the tool making responsibility of humans in this system may be considered countenance to technology transfer; therefore the design and practice must be respectful.

The Indigenous Evaluation Framework was formed by the American Indian Higher Education Consortium (AIHEC) to combine Western and traditional cultural assessments of values and protocols into a cohesive method for developing a curriculum based on the tribal traditional knowledge (Bowman, 2009). This approach of infusing knowledge from different views into the teaching of American Indian students at TCUs exposes the students to not only their own ways of knowing, but also western methods of learning, making them more eligible and able to compete (Crazy Bull, 2004).

TCUs are rooted in the values of the community they serve and seek research opportunities within their respective reservations and according to their charter (Cummins et al., 2010). This means that research should be based on questions linked to community needs. To determine if this community based research mission presents problems, when compared to western academics, Harala et al. (2005) conducted interviews with several faculty and staff at various Native and non-Native serving academic institutions and discovered some interesting differences between Native American and non-Native researchers. Some of the differences in paradigms between Western and Native American worldviews include the clash over how cultures think of nature (the Western researchers try to master it, the Native American try to live in harmony with it) and time (Western researchers oriented toward the future and Native American's oriented to the present) (Harla et al., 2005). With regard to forming relationships with the other, Western style academics appreciated the complexities of cultural interaction, while Native academics remained suspicious that they would remain the subordinate when collaborating with mainstream institutions (Harla et al., 2005). Western researchers expressed a goal of maintaining objectivity in research while Native

researchers believed that, because of the connectedness of all things, objectivity is impossible (Cummins, et al., 2010). Further, while indigenous research is done to benefit the community, Native critique the notion that Western research seems to result in more focus on, and benefit to the researcher (Harala et al., 2005). The study also revealed that, while Western researchers have begun to acknowledge the importance of community-based research, they have yet to recognize the native desire and necessity for consulting with tribal members (Harla et al., 2005). These two groups of researchers continue to differ in fundamental ways in their worldviews, academic organizational cultures, and their understanding of how research can be beneficial to the community (Harla et al., 2005). While Western scholars still base learning on quantitative objectivity and detachment, Native scholars argue that learning is based on context, relationships, integration, and community (Cummins, et al., 2010). In fact, so many Native American researchers questioned the validity of positivism as the basis for research that Harala et al. (2005) disputed its applicability for research in the Native American community. Most non-Native academics realize the difficulties for researchers with an indigenous point of view when attempting to adhere to positivist mandates of research (Harla et al., 2005). Native academics acknowledge that there is less of an emphasis to conduct positivist style research at TCUs (Harla et al., 2005). This separation from western ways of research could have an effect upon technology transfer at TCUs.

As noted, Native Americans have a number of doubts about the Western approach, and some scientists have observed that some Native American researchers are reluctance about research partnerships even if the result is projected to be beneficial their community (Harding et al., 2012). Trust is a problem between mainstream and tribal

scientists for a number of reasons. Most current, and previously discussed, is the drastic differences between Native and Western conceptions of knowledge (Harding et al., 2012). Secondly, some tribal researchers remain stigmatized and skeptical of Western research methods (Crazy Bull, 2004). Historically, Natives have viewed these research methods as significant instruments of cultural oppression for Native Americans (Harala, Smith, Hassel, & Gailfus, 2005). One such example of this was the way Westerners used the skull measurements of Natives in determining the land awarded in reservations (Harala et al., 2005). A third reason for mistrust is the fate of resulting research. For a scientist trained in Western science, knowledge is generated by an individual and once it is shared is free to be used by others (Crazy Bull, 2004). In tribal life, however, knowledge is viewed as part of the tribe's identity, with members told to keep the knowledge for the group (Zaffos, 2013). This conceptualization of knowledge derives from the history of the tribes as sovereign nations whose independence has been challenged numerous times (Crazy Bull, 2004). As a result, Native Americans perceive any threat to their culture as the threat to their people. Insofar as knowledge is culture, it is viewed as owned collectively by the tribe (Harding et al., 2012). The Ho-Chunk Nation's Tribal Research Code, for example, equates knowledge with the preservation of the tribe (Harding et al., 2012). As a result, all knowledge generated during a research project involving the tribe is construed by them as owned by the tribe (Harding et al., 2012). In cases in which the research involves generation of data that may be too complex for the tribe to understand, or in cases in which the results are to be published in mainstream research, partners are considered. Partnered researchers must acquire the

tribes' permission before writing or submitting first-person reports on cooperative studies (Hernandez, 2004).

To address tribal trust issues with Western researchers, Harding et al. (2012) presented a data sharing agreement model for community-based participatory research (CBPR) based on their experiences in a university-tribal collaboration involving the Confederated Tribes of the Umatilla Indian Reservation and Oregon State University. Harding et al. (2012) outlined the minimum requirements of a data sharing agreement that would be needed for community-based participatory research to avoid the pitfalls of data sharing in tribal contexts, such as cultural awareness issues and community priorities. Community-based research is ideal for TCUs because it has a wider variety of questions pertinent to the study than standard research, including reflection of the studies usefulness to the people within the community (Shore, Brazauskas, Drew, Wong, Moy, Baden, Cyr, Ulevicus, & Seifer, 2011).

To further understand the constraints related to Native/Western research projects, as well as demonstrating how they can be overcome using CBPR, Katz, Martinez, and Paul (2011) presented a project between university researchers and Indian Health Service nurse practitioners in Alaska. The partnership was initiated by a graduate from the university nursing program who wanted to improve adolescent health and the Indian Health Service in her community. A focus group was held with the community to gain a sense of the concerns with regard to adolescents. The issues identified were drugs, lack of cultural identity and lack of activities. Katz et al. (2011) demonstrated that CBPR can be enhanced by focus group participation with community members and the presence of a liaison, in this case the university student, to consider both the university and community

needs. This CBPR is a relevant example because the target Native American community held deep-seated negative views about research, and also because the study resulted in improved research, co-learning by the participants, and findings that are grounded in the community. Though focused on a demonstration of CBPR, the research suggests a few mechanisms by which technology transfer could be expedited in the context of Native American communities.

Native cultural considerations for technology transfer

Research projects and any associated technology transfer activities at TCUs are funded primarily through federal agencies; however, it is not evident that intellectual property produced from TCU research projects has been transferred to the commercial sector (AUTM, 2013). TCUs have been involved in numerous research projects, such as the National Aeronautics and Space Administration (NASA)'s Tribal Colleges and Universities Project, but exhibit no patenting compared to Western academic institutions (Brenner & Buckhalt, 2007). An analysis of the Association of Technology Managers information database has yielded no intellectual property protection recordings for technology transfer from TCUs (AUTM, 2013). No additional evidence in the literature can be found where intellectual property has been patented or officially documented.

Culturally sensitive research

Review of cultural issues, as they relate to TCU research in STEM fields, reveals that, while Native science has an understanding of technology that would enable transfer, some cultural aspects of research in tribal communities seem to inhibit transfer. A major issue for TCUs, in relation to the mainstream academic world, is the status of tribal research (Corbyn, 2011; Crazy Bull, 2004; Garrison, 2007; Nguyen & Aoyama, 2012).

While trained in Western ideas and theology, tribal scholars attempt to engage more in research beneficial to the communities in which they live and less in research based on mainstream technological advances (Cummins et al., 2010; Crazy Bull, 2004). While mainstream Western research wants to describe, organize, and define indigenous people in the context of Western thought, indigenous scholars conduct research from a perspective that supports the uniqueness of indigenous nations (Crazy Bull, 2004). This kind of research revolves around tribal traditions based in the belief of spirits, the perception of traditional ways, the study of linguistics and herbalism, and the understanding of biological and geological explanations of sickness and geography (Crazy Bull, 2004). The sometimes different methods of research between TCUs and mainstream universities may have an influence upon technology transfer.

Another barrier to technology transfer among TCUs is their lack of resources for conducting research appropriate for transfer. If research is undertaken in a manner conducive to community cooperation it could potentially compromise the validity of the research in the eyes of mainstream stakeholders (Cummins et al., 2010; Zaffos, 2013). To overcome this concern, TCU-based academics often partner with mainstream research institutions when conducting research (Davis, Givers, & Johnson, 2007). Even then, research often has to be replicated because of issues related to tribal mistrust and cultural misunderstanding and miscommunication with university partners (Davis et al., 2007).

TCUs are rich with knowledge but the traditional method of information distribution has not been technology transfer. Despite efforts to increase publication rates, the cultural orientation of TCU American Indian researchers often results in sharing the outcomes of their research orally, as opposed to publishing them (Vance, 2010). In

2007, for example, despite the production of more than 300 shared research projects, results were primarily shared in oral presentations at meetings or conferences; very few were published as academic papers (Vance, 2010). However, recent literature indicates that the publication of relevant research and the transfer of knowledge through means other than by oral communication is increasing (Vance, 2010). In addition, the increase in STEM research through TCUs may encourage technology transfer in the future.

Graduate student presence

Universities utilizing graduate students, as is common practice in U.S. institutions, tend to be more successful obtaining patents and conducting technology transfer (Gurmu, Black, & Stephan, 2010). Research faculty tends to see graduate students as more competent than undergraduate students and hire them to assist in ongoing projects (Gurmu et al., 2010). These larger schools have high numbers of graduate students and employing them increases the speed and frequency of research output (Gurmu et al., 2010). Utilizing graduate students for research benefits the schools and students because it is a good training model, is less expensive, and tends to discover newer ideas more quickly (Gurmu et al., 2010). This is an important point to note when explaining research at TCUs because, as mentioned at the beginning of this chapter, only two TCUs offer graduate programs, placing TCUs at a disadvantage for research production when compared to mainstream institutions.

To determine if there was a relationship between the number of postdocs at a university and its patenting activity, Gurmu et al. (2010) studied the number of patents issued by 159 Carnegie institutions in fields ranging from drugs and medical to computers and communications. They found that the patent output rate of a university

relates positively with the number of postdocs and PhD students. According to the information presented, the importance of academic make up is critical to the process of technology transfer and patent acquisition. The results of Gurmu et al. (2010)'s study suggest that, while TCUs benefit from a sufficient number of available undergraduate students, they do not have access to adequate research leadership. Increasing the number of graduate and postdoc research faculty at TCUs will create more potential for technology transfer.

Hiring more faculty

Many tribal colleges receive funding from the federal government, but their funding is consistently inadequate, unpredictable, or contested, causing administrators to devote a significant portion of their time each year lobbying for their funding (Pekow, 2007). Vance (2010) reported that most TCU faculty do not have time or support for research, and therefore do not publish enough to support this part of their careers. Tribal colleges and universities may not have the time to address technology transfer because basic educational needs take considerable resources and time. TCUs constantly struggle with funding, building, and personnel issues; high staff turnover rates make the cost of training new staff onerous (Voorhees, 2004). Of the staff employed at TCUs, 37% of faculty members are American Indian, younger, and paid less than their counterparts in other institutions (Voorhees, 2004). Furthermore, position are likely held by faculty in their first college-level teaching job, few possessing the doctorates or master's degrees necessary for research projects to be considered for funding or technology transfer (Voorhees, 2004). The status of the TCU faculty may also hinder research activities eligible for technology transfer. The mandate to increase research has become more

urgent as technology transfer has made university-based research a potentially lucrative source of additional funding (Powers & Campbell, 2009).

The current state of technology transfer at TCUs

The TCUs are interested in technology transfer, as evidenced by a few articles that touch on the subject; however, no evidence of any TCU establishing an intellectual property office or official technology transfer office can be found. What little can be found online, also indicates no concrete evidence that TCUs are actively engaged in technology transfer. The Center for Indigenous Health Research website provides a data sharing agreement sample that TCUs can use to guarantee the ownership of research outcomes and dissemination (intellectual property rights). The document outlines TCUs intellectual property rights regarding the publication or commercialization of research findings. This sample agreement is an example of how to protect TCUs from unauthorized sharing and giving TCUs ownership and control over data and research findings (Center For Indigenous Health Research, 2012). In addition to sample research agreements, an institutional review board (IRB) is another example of controlling research and study results on projects conducted at TCUs (Hernandez, 2004). These two examples are the first steps towards establishing any sort of technology transfer agreement.

The American Indian Higher Education Consortium (AIHEC) plays a very important role in promoting technology transfer in TCUs by providing the leadership and influence necessary to promote and strengthen research activities and technology transfer (AIHEC, 2012). The consortium advocates on behalf of their member institutions, seeks to change public policy, promotes research, and facilities the enhancement of program

initiatives to support tribal sovereignty (AIHEC, 2012). AIHEC has signed a memorandum of understanding with the United States Department of the Interior (DOI) with an aim of working together to fulfill the mandate of each institution (AIHEC, 2012). Among the objectives this partnership is to strengthen and sustain the TCUs capacity (AIHEC, 2012). This will allow TCUs to participate in DOI research and technology transfer in areas such as natural resources, clean and renewable energy as well as other sciences or fields critical to the DOI by fully integrating TCUs into the DOI's bureau programs, resource opportunities, and services (AIHEC, 2012). The assistance that the DOI will provide to TCUs includes research and facility support, loaning of executives for research projects, technology infrastructure and support, and technology transfer to applicable institutions (AIHEC, 2012).

The AIHEC also partners with the NASA Tribal Colleges and University Program (TCUP) that supports various activities designed to build the capacity of TCUs and their ability to provide high-quality STEM programs and conduct NASA-relevant research (AIHEC, 2012). In addition, the AIHEC partners with the American Indian Science and Engineering Society (AISES) and the American Indian Research and Education Initiative (AIREI) to support and provide community-based energy research and technology transfer projects (AIHEC, 2012).

TCUs are also land grant colleges, as of 1994, which may help increase research opportunities through the support of the Morrill Act of 1862 that mandates all land grant colleges to undertake research that will better the lives of the citizens in their community (Mortensen, Nelson, & Stauss, 2001). As a result of this Act, a typical land grant university has agricultural departments, bio-systems engineering departments, and

stations for research across the state. The original land grant universities have grown to be large institutions that can attract additional research funding, are experienced, and politically influential, and have the resources to transfer research findings to the public (Mortensen et al., 2001). Unfortunately, the TCU land grant colleges have yet to realize the same potential.

Even with all of these partnerships and advancements within TCUs, there is still a glaring issue regarding the lack of technology transfer occurring in these institutions. There are unique issues that TCUs face in technology transfer, however the foundation is there. In an attempt to further technology transfer efforts, there are several successful models of technology transfer that are used by other universities (Lipinski, Minutolo, & Crothers, 2008). Perhaps by implementing appropriate models and analyzing the results, researchers can better understand the barriers affecting successful technology transfer within TCUs so that TCUs can more effectively review technology transfer within their research plans and evaluate the skills required to handle more advanced STEM coursework in an effective manner (Shah, 2009).

Increasing TCU technology transfer, evaluating successful models.

In an attempt to minimize the potential problems encountered during the transfer processes, research study results have attempted to present a best practice model for technology transfer (Bertrand, 2010; Harman, 2010; Sterckx, 2011). However limited success has been presented because of differences in methodology, whether the transfer is targeted for industry or sales, and variations of previous models across time and space (Brenner & Buckhalt, 2007; Choi, 2009; Geoghegan & Pontikakis, 2008; Povoa &

Rapini, 2010; Wahab, Rose, & Wati Osman, 2012). A breakdown and discussion on the characteristics of these various models follows.

Tribal college faculty research model

On the basis of native science principles, Davis, Givers, and Johnson (2007) created a model for STEM research to be conducted in a tribal college setting. The tribal college faculty research model includes Western ideas but is based on Native science concepts and focuses on the interrelatedness of the world. Targeted on the development of STEM research through undergraduate participation, the model is focused on student-centered exposure to methods of scientific inquiry by using prayer and ceremony to continually determine why research for a particular project should be conducted; how will it help people? How will it affect the interconnectedness of all life? In summary, Davis et al. (2007) outlined how Native science-based research would be conducted at a TCU. The tribal college faculty research model also acknowledges enough of mainstream science protocols to expedite research and obtain results. This model could serve as a foundation for technology transfer by which developers of technology transfer in a TCU could work their way through a reflection on cultural values to arrive at a decision to transfer a technology.

The technology life cycle model

Informed by an extensive review of existing technology transfer models, Business Asia (2008) developed the Technology Life Cycle Model, covering the planning, execution, and implementation phases of technology transfer. Though created for the purpose of combating the failure of technology transfer in a global context, the Life Cycle Model provided strong evidence that a best practice technology transfer model will

be a holistic approach focused on the relationship between the transferor and transferee, ensuring that the transfer of knowledge does not stop once manufacturing begins (Business Asia, 2008). Unlike other models, the Life Cycle Model provides a more in-depth approach to the communication between partners and addresses the possible trust issues between Native and Western researchers. However a potential problem with this model is the time and expertise required to properly manage the entire process, something that many TCUs do not have at this time. While the Technology Life Cycle Model is good in some regard, the Concerns-Based Adoption Model (CBAM) may offer a simpler approach.

Concerns-based adoption model (CBAM)

Two schools of thought exist pertaining to technology transfer; one seeks to characterize technology as distinct from science and emphasizes its ability to help human beings do things, the second breaks down technology into parts: object, process, knowledge, and volition (Choi, 2009). As an object, technology is a physical embodiment that can extend human possibility, as a process it does things effectively, and as volition, it is put to use with an aim in mind and with a human element (Choi, 2009). Based on an understanding of these dimensions, a more holistic model of technology transfer has been developed; the Concerns-Based Adoption Model (CBAM) (Choi, 2009). Unlike other models mentioned the CBAM goes beyond simply viewing technology as a process but also addresses how it is accepted and used by recipients. In this model, the difference between stakeholder's needs and the understanding about the process are considered; a university might see technology transfer as a way to improve society, but businesses see it as a way to make money (Choi, 2009). For this reason, it is

not just the technology being transferred, but also elements of knowledge and process too. It also addresses how social structure and communication can influence the process of technology transfer through decisions affecting the degree to which the innovation leads to positive or negative consequences (Choi, 2009). Change is experienced differently by communities and individuals depending on what stage of acceptance they are going through, discussed below (Choi, 2009). This makes it important for the party implementing the change, or technology transfer, to know where their target recipients are in terms of their receptivity. This can be determined by the degree to which the recipients are moving through the following phases of acceptance; awareness, informational, personal, management, consequence, collaboration and refocusing (Choi, 2009). These factors must be taken into consideration by the managers of technology transfer to create opportunities for adoption, and to use those opportunities to exploit periods of regular use of the technology to generate new insights. Thus, the donor must work to reduce the knowledge barriers involved in adoption while the recipient improves know-how. For Choi (2009), this meant that technology transfer best practice can only occur in a learning organization because education and training is paramount. From this line of thought, he suggested that the invisible dimensions of technology transfer, education and training, are probably much more critical to success than the technical aspects of technology transfer (Choi, 2009). According to Choi (2009) the primary test of the degree to which technology transfer has been successful occurs during the introduction of the technology, if the new technology then stimulates further innovation in the community, it has been successful. This means that in order for technology transfer to occur, human capital must be increased, the willingness of both parties must

be assessed, collaboration must be encouraged, and training must be undertaken (Choi 2009). This so-called role shifting model of technology transfer focuses on the extent to which it leads to further innovations in the recipient party.

The Information and Documentation model (I&D)

Krucken, Meier, and Muller (2007) argued that the debate over the ethics involved in technology transfer is not decreasing. In an attempt to minimize the challenges felt between the academic and commercial sides, Krucken et al. (2007) developed three ideal-type models of technology transfer occurring across the academic-industrial divide: the Information and Documentation model (I&D), the Cooperation model, and the Blurring of Boundaries model. The I&D model typically pertains to large information centers which monitor scientific advance in academic institutions and then notify industry partners when an opportunity for advancement is presented (Krucken et al., 2007). These information centers attempt to organize scientific knowledge at the same accelerated pace that it is being developed but have little to do with the partnerships between scientists and entrepreneurs (Krucken et al., 2007). Instead, the I&D model focuses on the linear relationship between the generation of knowledge and the ways in which it is utilized (Krucken et al., 2007). In the U.S., this model was exemplified by the National Science Foundation, which created an Office of Science Information to further research and development after the Soviet Union's Sputnik launch in 1957 (Krucken et al., 2007). Although TCUs may not be large information centers, a big portion of their research funding comes from NSF (AIHEC, 2012). Therefore, further investigation into how this model may be an effective one to use for TCUs with NSF funding will need to be conducted.

The Cooperation model

The second model of technology transfer, the Cooperation model, arose in response to the complexity of the transfer process (Krucken et al., 2007). In this model, scientists and practitioners must work together to exchange ideas through immediate personal contact (Krucken et al., 2007). Technology transfer is treated as a dialog of partners, as a two-way street, utilizing technology transfer offices (TTOs) and other mediating positions as the go-betweens during the process (Krucken et al., 2007). The NSF fostered university-industry interaction through the creation of Cooperative Research Centers and Innovation Centers (Krucken et al., 2007). The TCUs have a long history of collaborating on projects and undergraduate research and technology transfer may be one of those areas.

The Blurring the Boundaries model

The Blurring the Boundaries model assumes that the boundaries between academia and industry are becoming permeable and diffusible (Krucken et al., 2007). In this model, universities have become entrepreneurial or economic agent in their own right (Krucken et al., 2007). The model also sees academic knowledge as embedded in a comprehensive and highly complex innovation process (Krucken et al., 2007). In this system there are numerous feedback loops, replacing the dyadic straightforward Cooperation model with a complex network model in which it is difficult to determine who is academic and who is industrial (Krucken et al., 2007). The involvement of universities in the development of Silicon Valley is a typical example of the Blurred Boundaries model; the universities and companies worked together to spin off companies and develop partnerships around the technology developed (Krucken et al., 2007).

Studying the activities associated with the technology transfer within Silicon Valley may provide a good illustration of similar opportunities for TCUs to partner with local or regional industry.

Technology Transfer Offices (TTOs)

The Technology Transfer Office (TTO) is a formal organization within the university structure that handles intellectual property, its protection, transfer, licensing, and all other related patenting processes (Huang, Feeney, & Welch, 2011). The TTO is primarily responsible for the identification of patentable inventions, initiating the patenting process, and license negotiations among the parties (Huang et al., 2011). A TTO can vary immensely in size and scope, depending upon several factors, such as size of university, research activity, and administrative emphasis upon technology transfer (AUTM, 2013).

Lipinski, Minutolo, and Crothers (2008) noted that even though many colleges and universities have established technology transfer offices (TTOs), there remains a wide variation in the level of successful technology transfer experienced by universities. Research has sought to explain such differences by creating various models (as above), however differences between these models are not specific enough to explain all the reasons why some universities succeed and others fail at technology transfer (Lipinski et al., 2008). There is no mention of TTOs at a TCU in the available literature.

Considering all of the variation in the available models of best practices and the previously discussed methods of Native research a traditional linear model of technology transfer, involving discovery, disclosure, evaluation, patent, market, negotiation, and license, is a poor fit. A network theory approach, like those described above, more

accurately describes and accommodates the technology transfer process needs of TCUs (Lipinski, et al., 2008). Lipinski et al. (2008) explored some of the various licensing strategies that universities could choose in the context of these network models. TTOs serve as industrial gatekeepers for universities; however when an institution utilizes a network type approach to technology transfer, these TTOs can experience difficulty attempting to work with industry's revenue based models (Lipinski et al., 2008). This disparity causes at least 20% of scientists to refrain from sharing their knowledge with TTOs (Lipinski et al., 2008). To decrease these effects, TTOs must broaden their understanding of business so that they can recommend appropriate placement of technology and match the intellectual property of the university to the company most likely to have the resources needed to commercialize it (Lipinski et al., 2008). In short technology transfer, at present, will be most effective operating within a university's culture; however, to realize their full potential, universities need to ensure a TTO is properly supported and trained, no matter which model a TCU is operating under.

Gurmu, Black, and Stephan (2010) states that patent output rate of a university relates positively with the presence of a TTO. At the same time Geoghegan and Pontikakis (2008) argued that while universities have traditionally operated as passive repositories of scientific know-how, their new role as agents of knowledge creation and diffusion has begun to expand that function. Universities now exist in a more entrepreneurial spirit, increasingly collaborating with government and industrial technology as a part of the *triple-helix creativity spiral* (Geoghegan & Pontikakis, 2008). This new economic role for the university has forced many to rethink their science and technology policies (Geoghegan & Pontikakis, 2008). While increases in technology

transfers have occurred, some universities have experienced tensions during this transitional phase (Geoghegan & Pontikakis, 2008). In Ireland, staff reported feeling pressured into a more commercially goal-oriented state of mind. In addition, traditional measures of performance have been displaced by other measures involving research productivity (Geoghegan & Pontikakis, 2008). TTO directors report gaps in technology transfer arrangements and note that successful transfers rely on high levels of sophisticated collaboration, the experience of the parties involved, and whether or not they know, or have previously worked with each other (Geoghegan & Pontikakis, 2008). At the institutional level, ineffective management of university TTOs, bureaucratic inflexibility, time frames, and poorly designed rewards systems can inhibit transfer (Geoghegan & Pontikakis, 2008). The lack of evidence supporting the operation of any TTO at a TCU appears to limit the utilization of the Blurring the Boundaries model for a typical TCU. This appears to be the same of all the models explored in this literature review, TCUs may not have the capacity to build a technology transfer program nor establish their own TTO.

The engaged university and translational research.

A new horizon for technology transfer in institutions like TCUs may be available as a result of changing relations between universities and communities. Engaged universities promote the concept of mutuality of university and community as the basis for establishing research collaborations (Begun, Berger, Otto-Salaj, & Rose, 2010). In some fields, like social work, community-based participatory research has emerged as a way to bridge gaps between the production of research knowledge at the university and its use for changing community practices (Begun et al., 2010). This model has called for

the development of multidimensional, nonlinear, multidirectional partnerships between university and community (Begun et al., 2010). The term translational research, describes the unidirectional nature of research findings and community needs, or from developer to user (Begun et al., 2010). This concept would foster these co-learning environments, initiate community-driven projects, disseminate useful findings, and use culturally appropriate strategies in the process (Begun et al., 2010).

The Technology Exchange concept was introduced in 2010, it is multidirectional in nature and recognizes the iterative nature of collaboration while emphasizing process and seeking out synergy as the mechanism by which transfer can be expedited (Begun et al., 2010). Technology Exchange is a two-way process in which scientists learn from practitioners what problems need to be addressed and then offer insight that may lead to advances (Begun et al., 2010). This would replace the traditional unidirectional model which places very little cooperation between universities and community organizers in which research was simply imposed on the community in ways that made them feel separated and disrespected (Begun et al., 2010). In addition, Begun et al. (2010) argued that Technology Exchange encourages long-term consideration of the project, including its effects and which partners to involve and why. Knowing why each partner is involved will improve the likelihood of favorable outcomes in the collaboration because partners can navigate contextual constraints such as different learning styles and cultural attitudes (Begun et al., 2010). Overall, while focused on social work, Begun et al. (2010) outlined how university-community partnerships can serve as the basis for improved technology transfer. The extent to which TCUs are inherently engaged universities working with

communities mean that a technology exchange based research model could serve as the basis for increased technology transfer.

Global and federal factors contributing to efforts of technology transfer development.

Technology transfer activities continue to receive substantial funding support from the federal government through organizations like NSF (Matthews, 2012). Some researchers view the emergence of technology transfer as a competitive focus in university life as a side-effect of the globalization of the economy (Goransson, Maharajh, & Schmoch, 2009). In the United States, technology transfer involves procuring patents from university discoveries that make a profit for that institution's research and development laboratories. The Bayh-Dole Act, implying that knowledge is business, has focused U.S.-based technology transfer on acquiring revenue-generating patents from research (Goransson et al., 2009). Whether or not this approach can be applied to less developed entities remains a question (Goransson et al., 2009). If an institution has only a modest development in the industrial sector as well as limited government resources, it is likely that the level of innovation activity is low (Goransson et al., 2009). This also means that some of the necessary partners needed for successful technology transfer are missing (Goransson et al., 2009). That is, the institution lacks the capacity for research development and only minor technology transfers are occurring. Using a macro, meso, and micro model to discern levels of capacity, Goransson et al. (2009) noted, for example, that while Can Tho University in Vietnam is helping develop agricultural techniques useful for the local economy on the micro and meso levels, it has little capacity to develop ideas or compete on the global, or macro level. Even in countries

where the economy is strong there remains a substantial gap between the local culture of the university and enterprise, especially in areas where the idea of science existing separately from industry persists (Goransson et al., 2009). In these cases, a solution might be to orient universities toward more applied science topics in the manner of a polytechnic (Goransson et al., 2009). Goransson et al. (2009) concluded that a university's or culture's ability to transition from the science v. industry paradigm to the new global paradigm of technology transfer is likely to be site-specific and path-dependent.

The takeaway point from the previous analysis of the strategies adopted for technology transfer by countries and cultures with variations in technology transfer capacity, is that the Native American cultural community has a choice to make: does it join with the technology transfer model that has developed in mainstream American culture or seek to find a role for itself in a highly developed country? Or, alternatively, does it perceive itself as a kind of 'developing' economy and work through the problems presented by the limitations of its community's absorptive ability to expand intellectual capacity? The difficulties involved in building up intellectual capacity strongly suggest assimilation as the fast track to improved technology transfer in TCUs (Goransson et al., 2009).

Technology transfer has been expedited by laws such as the Bayh-Dole Act of 1980, which gave patent rights and invention licenses to federally granted researchers to encourage technology transfer (Colaianni & Cook-Deegan, 2009). Prior to the Bayh-Dole Act, a funding organization like the National Institute of Health (NIH) would have controlled the patent (Colaianni & Cook-Deegan, 2009). The Act was designed to

encourage technology transfer by giving inventors an incentive to market their discoveries and encourage current patent holders to seek extension beyond current term (Colaianni & Cook-Deegan, 2009). While some universities, such as Columbia University, profited from these decisions, their subsequent efforts to extend patents involved considerable controversy as well legal expenditures (Colaianni & Cook-Deegan, 2009). Some scientists were even offended by the process, suggesting that it may hinder laboratory research because of high costs and strict patent protection rules (Colaianni & Cook-Deegan, 2009). Universities were also criticized for behavior unbecoming to a nonprofit academic institution for suing other institutions over patent rights (Colaianni & Cook-Deegan, 2009). In one case at Columbia, while the inventors took in $110 million, the process generated $250 million for further research and development for the institution allowing them to spread funding to the Department of Biomedical Engineering, the School of Engineering and the Earth Institute (Colaianni & Cook-Deegan, 2009). Colaianni and Cook-Deegan (2009) argued that a revenue generation policy is helpful in that it rewards institutions that are successful in generating inventions, channels revenue into research and education, and diverts some revenue from private industry. However this process may not benefit small institutions, such as TCUs in the same ways. The legal fees involved in enforcing patents are considerable, and, in the example above, research had been ongoing for twenty-two years before finding the patentable discovery (Colaianni & Cook-Deegan, 2009). While the Columbia's case netted great profits, small institutions, such as TCUs, do not have the ability to compete at this level nor are their research departments developed to the level required to acquire such patents.

Conclusion

This literature review found a number of barriers to the development of technology transfer at TCUs (Bowman, 2009; Cullinane & Leegwater, 2008; Hawkins, 2011; His Horse is Thunder, 2012; Karlberg, 2007; Kicking Woman, 2011; Murray, 2006; Pekow, 2007; Shah, 2009; Swisher, 2004; Talahongva, 2009; Vance, 2010;). Historically, TCUs have focused on educating underprepared first-generation students (AIHEC, 2012). As a result, research has not become part of the culture of the TCU, or, if it has, most faculty members have not pursued mainstream channels in the publicizing of the research. Nonetheless, efforts have been made to improve the research profile of TCUs both by encouraging faculty to conduct and publish more research, and by having students participate in more research in STEM field courses. Building a solid basis of research in STEM fields would serve as a platform on the basis of which more technology transfer could develop. This review also found that technology transfer itself, even in best practice, remains a controversial process surrounded in a great deal of uncertainty (Bertrand, 2010; Brenner & Buckhalt , 2007; Choi, 2009; Geoghegan & Pontikakis, 2008; Harman, 2010; Matthews, 2012; Povoa & Rapini, 2010; Sterckx, 2011; Wahab, Rose, & Wati Osman, 2012). Not only are the mechanisms of technology transfer understudied, but also what influence individual and organizational characteristics have on technology transfer. This notion provides both opportunity and additional barriers to TCU technology transfer.

The most advantageous trends in technology transfer development, in terms of benefiting TCUs, is the movement toward translational, community-based research, and the emergence of a more collaborative, network-oriented model of technology transfer.

These trends may allow TCUs to position themselves in ways to contribute to and benefit from technology transfer. It is apparent that the cultural orientation of TCUs and their mission to remain accountable to the reservation community has, to a certain extent, limited the potential for TCU research and technology transfer (Corbyn, 2011; Crazy Bull, 2004; Garrison, 2007; Nguyen & Aoyama, 2012). It is not clear if native science's views of research and technology would encourage or inhibit technology transfer; however TCUs appear to have adopted the community-based participatory research model that has emerged in the research discourse. This mode of research provides a way to expedite technology transfer, particularly if the TCU is only interested in transferring technology to the community for its benefit.

Chapter 2 Summary

Although the Bayh-Dole Act has granted TCUs the authority to protect and control intellectual property that results from research projects, it is clear from the literature review that TCUs have much work to do in order to conduct technology transfer. TCUs appear to have the conditions to support technology transfer, and they are increasing their research capacity and hiring more faculty members with research skills and potential, but the idea of TCU leadership support is an area that needs to be addressed as not all TCUs understand how technology transfer fits within their mission and vision statements. For TCUs, technology transfer needs to be directly associated with local or regional economic development. The review found a number of community-based participatory research projects conducted by TCUs that would lend themselves to technology transfer; these projects embody some of the more advanced relational models described in a number of the technology transfer best practices.

Currently, technology transfer at TCUs remains, at best, a fledgling proposition. Many constraints need to be overcome before TCUs can fully exploit the commercial potential of research and create a new stream of funding for college support. While research suggests that expanding both faculty in STEM and research in STEM will have a positive effect on technology transfer activity, it is not guaranteed; and even if it was, many TCUs lack the funding or support to make this happen quickly.

The area of technology transfer has been an integral part of large research universities that have the resources to support such activities. Smaller colleges, such as the nation's TCUs have very little experience in technology transfer. The study proposed here attempted to determine if leadership at selected TCUs was aware of the opportunities and challenges that technology transfer presents.

Technology transfer can provide an institution and community with financial and other benefits. Through this study, approaches appropriate for TCUs have been evaluated in an effort to understand the potential affects technology transfer may have had upon that TCU and the community they serve. Technology transfer between universities and industry has been occurring for a number of years and with the increase in the information and knowledge-based economy, TCUs continue to seek additional approaches for economic development on their respective reservations.

Chapter 3

Methodology

The purpose of this research study was to explore technology transfer at TCUs and discover factors that may influence its implementation. It is important for TCUs to have the ability to pursue the commercialization of research results through collaboration with private industry partners. Institutions that conduct innovative research and transfer the results into commercial assets gain revenue and increase their reputations. They are perceived as colleges with credible research facilities, which attract funding agencies (Perry, 2009). With so much at stake one would expect this to be a well-documented topic; however, a review of the literature exposed a lack of information regarding technology transfers at TCUs. Results from this study have the potential to increase the discussion and literature regarding technology transfer activities at TCUs. Also, it may provide insights into how technology transfers will take place at TCUs. Additionally, the exploration of factors that are thought to impact technology transfer, such as undergraduate research activity, faculty credentials, facilities, and other campus resources, would bring focus to this topic at the participating institutions and might lead to action.

The following research method and design section discusses ways to investigate the state of technology transfer activities at TCUs, and addresses methods to better understand technology transfer and its relationship to undergraduate research. The chapter outlines the rationale for the methodology ultimately used in this project and includes the exploratory research questions, the research method and appropriateness of the design, population and sampling, informed consent, data collection, data analysis, and

the presentation of the data. The chapter concludes with a summary of how the research methodology proceeds to the conclusion of the project.

Research Method and Design Appropriateness

Research methods include quantitative, qualitative, and mixed methods, with variations within each method. Quantitative method involves broad investigation of trends across industry, geography, strategy, and other levels of human endeavor (Cooper & Schindler, 2008). Numerical representations make it possible to sample larger sizes, demonstrate rigor, and emphasize validity of research results (Laher, 2016). Thus, factors and variables carry numerical representations. Qualitative research method involves a narrow focus on a problem. Such focus necessitates a researcher's personal attachment to the subject during the period of research (Miles & Huberman, 2013) in which a researcher has the opportunity to gain rich insight into the phenomena of study (Mikuska, 2014).

Research methods can include quantitative, qualitative or a mixture of both methods. Quantitative methods are generally deductive and designed to test pre-specified concepts. They typically involve a broad investigation of trends across industry, geography, strategy, and other levels of human endeavor (Cooper & Schindler, 2008). Numerical data is typically gathered through questionnaires, interviews, and reviews of secondary records. These methods are considered to be more generalizable since they are capable of covering a breadth of information across a large number of cases. Qualitative research methods are primarily inductive and used to generate ideas and build theory. These methods often involve a narrow focus on a problem or condition. Data gathering techniques include focus groups, in-depth interviews, observations, and document

review. Mixed method is the combination of quantitative and qualitative methods in research (Gibson, 2016). A researcher can utilize quantitative techniques to gather numerical representations to compute trends, sequences, and simulations. At the same time, the process may include qualitative techniques to gather data to compare personal responses with findings that arise from numerical permutations (Cooper & Schindler, 2008).

A quantitative research method was not appropriate for this study, as this approach involves numerical data gathered in a structured and controlled environment (Neuman, 2006). Furthermore, the research question is not a narrow, and the specific survey questions work better with measurable data (Cooper & Schindler, 2008). A mixed methods study approach, which also uses statistical analysis of quantifiable numerical data in addition to themes and codes to describe study results (Gibson, 2016), is also inappropriate. Preliminary evidence suggested the existence of quantifiable numerical data concerning TCU technology transfer was in question. In fact, with so little known about this issue, developing a quantifiable survey instrument was premature at that point. Research methods capable of providing a level of flexibility to react to data and information as it emerges during the study were needed. Therefore, the qualitative method was appropriate for studying technology transfer activities at TCUs.

Lewis, Saunders, and Thornhill (2009) pointed out that inductive research approaches aim to understand and generate substantive information about the nature of a phenomenon or problem in the way that the phenomenon occurs. Inductive approaches are appropriate for working on issues that have not been explored or have limited data (Gioia, Corley, and Hamilton, 2013). Qualitative research methods encompass many

designs and techniques, including phenomenology, ethnography, grounded theory, narrative design, and case study. Although they are all inductive, each design has certain strengths and weakness and may not be an appropriate technique for studying technology transfer activities at TCUs located on Native American reservations.

Phenomenology involves investigating the lived experiences of the research subjects. In such a study design, a researcher will make personal contact with each respondent in order to learn first-hand the participant's personal encounter with the research problem (Moustakas, 1994), and explore the subject's conscious experiences (Gill, 2014). To accomplish a phenomenological study, a researcher would schedule a time to meet with each participant in a place conducive to relay information. The investigation circumstances, time, and place would be free of encumbrances such as intrusion by others and interference from items in the of the interview space. These may include things like digital recording devices, digital video recording devices, and telephones. Since the personal lives and experiences of TCU functionaries do not constitute critical factors in the proposed research, the use of phenomenological design was not appropriate.

Ethnography involves investigating the lives of people or other mammals in their habitats. In such a design, an investigator interacts with the subjects of the research in order to learn how they do what they do, as well as under what circumstances they do those things (Marshall & Rossman, 2011). Such a study reveals elements that are ordinarily out of bounds to others who are not part of that enclave. This design consumes time, as the research subjects do not do the same things every passing day. Ethnographic researchers delve into the world of their subjects over an extended period before

considering their findings satisfactory (Nwosu, Nwosu, & Nwosu, 2013). Using ethnographic design could in time lead to knowing how TCU functionaries conduct their business. However, this study is strictly focused on technology transfer activities at TCUs and needed to use a method that gets to that point in a timely fashion. Therefore, ethnography was not appropriate.

Grounded theory techniques involve investigating phenomena to learn why it exists in the way that it does in an attempt to build and confirm theory. In the process of grounded theory research design, philosophical explanations emerge that circumscribe the subjects of the study (Strauss & Corbin, 1998). Furthermore, the emerging theories may not necessarily explain the phenomena. According to Apramian, Cristancho, Watling, and Lingard (2016) when using grounded theory, it is best to understand that it is designed to test theory and generate arguments that may accurately ascribable to the phenomena in question. Gaining an understanding of the activities TCU's are involved with to further technology transfer at their institutions does not require the discovery of underlining theories. Therefore, grounded theory design was not appropriate for this study.

Narrative design involves the use of any and all media available to a researcher to build a story around the phenomenon in question. Researchers may collect data from a the subject's old and new pictures, personal and family histories, observations, discussions, personal biographies, diverse information stored on computer discs, and anything that can convey meaning to the investigator (Holstein & Gubrium, 2012). Although it may be a useful part of any research project, it is not necessarily a standalone

technique for fully understanding the phenomenon in question. Therefore, this design was not appropriate for gaining better insights into TCU technology transfer activities.

A case study, according to Tellis (1997) satisfies the three tenets of qualitative research methodology: describing, understanding, and explaining. Case study design involves the identification of phenomena pertaining to a company, a species or group of people, a profession, a situation or event (Yin, 2012). It facilitates the discussion of ideas and opinions through an interview process, rather than direct observation or group discussions, as found in other qualitative research methods (Neuman, 2006). However, according to Miller and Jones (2001), case studies normally do include in-depth interviews or direct observation of the target population or organizational members, or both. This method has several advantages over other information gathering techniques such as the Delphi method. The Delphi approach is iterative and facilitates the building of consensus over time (Nworie, 2011) whereas a case study can be designed for a single onsite interview of the participants. Case study designs can also use in-person or telephone interviews to gather information from participants which work well for geographically diverse studies. It offers the flexibility needed to follow leads generated during the interview process. It may also allow for greater participation from the target population, since it does not require the interviewees to possess a high level of expertise on the topic of interest.

A qualitative exploratory case study method was selected as the most appropriate research design for this study. According to Marshall and Rossman (2011), a case study is appropriate when the case to be studied has clear boundaries. The topic of this research, technology transfer activities at TCUs, is specific and clear. Additionally, the

case study method is uniquely suited to answer how and why questions regarding an understudied subject (Yin, 1994). The apparent void in information makes an inductive research approach, like case study, the best methodological option. Finally, this method is particularly well suited for the population under study. Historically, the manner in which research and assessment has been conducted in tribal communities has created a degree of mistrust of outside researchers and their methods (His Horse Is Thunder, 2012). As a result, researchers became more educated on cultural differences to ensure a degree of cultural sensitivity when conducting research in tribal communities (Crazy Bull, 2004). A trend is to utilize methods which are more congruent with native cultures where tribal knowledge, tradition, and storytelling are seen as legitimate ways of knowing (Kovach, 2010). The exploratory case study approach was selected because it allows for data gathering techniques more in line with traditional Native American customs and practices of knowledge transfer. Because indigenous ways of knowing are typically built on an oral tradition of storytelling and shared knowledge, utilizing qualitative data gathering techniques allow participants the opportunity to tell their story with regards to technology transfers at their TCU and on their reservations. TCUs are diverse in size, location, and research focus, so understanding the contextual factors surrounding each institution is important. Open response storytelling will not only encourage contextual detail, it will be a welcomed approach to researching the technology transfer issue. This research method provides a structured technique appropriate for both the population and the problem under study.

An exploratory design utilizing multiple sites was the most appropriate direction for this study. This format permitted the researcher to gather the opinions of key

stakeholders, in addition to a thorough review of archival data at several TCUs. Exploratory case studies are designed to use multiple sources of data during causal investigations (Tellis, 1997). Technology transfer issues are complex and required the input from multiple well-informed stakeholders to build understanding. Five key individuals from each of the four selected TCUs participated in this study. The key respondents included TCU presidents, vice-presidents, faculty, and researchers. The selected experts offered broad, but informed, perspectives on technology transfer activities during the interview sessions. This technique provided perspectives from multiple angles within the topic of technology transfer at TCUs. The angles were provided through the interviews, archival data, and field notes of the researcher. While some quantitative analysis may have been useful, the exploratory nature of this project lent itself much more to the description and explanation of the phenomenon of interest (Bromley, 1990). Ultimately, this project was able to utilize qualitative data gathering techniques and analysis to uncover the existence, method, and rate of technology transfer activities at four TCUs.

The design of this qualitative exploratory case study primarily involved senior level administrators and faculty at multiple TCU sites, with additional support of archival data and field notes. The case under exploration is the unknown factors that appeared to be inhibiting technology transfer at TCUs. This section presents arguments for the appropriateness of using a qualitative method with exploratory multiple case site design as opposed to a quantitative or mixed methods. In addition, the selection and appropriateness of multiple site case study design was discussed along with how this design accomplished the purpose of this study.

Population

The 37 American Indian Higher Education Consortium (AIHEC) member TCU institutions were the population under study. AIHEC membership was selected because it provided a straight forward framework for identifying TCU institutions. The selected institutions from the population are: Institution A, Institution B, Institution C, and Institution D, covering a wide geographic area, coded to maintain institutional confidentiality.

Sampling

Purposive sampling led to the selection of 20 TCU participants from the four pre-determined TCUs. Purposive sampling is used when a certain population is needed because of some characteristic of the study (Miles & Huberman, 2013). In this study, knowledge about technology transfer, undergraduate research, and institutional culture were the characteristics sought after. The sample included the president of each institution and four others of which were recommended by the president. The additional respondents included one or more of the following: vice presidents, deans, institutional researcher, scientific researchers, instructors, professors, or other staff members. Of critical importance was the use of multiple sites for this study. Attaining data saturation and convergence of the data across the sites were possible in this study. The phenomenon of convergence aided in linking the similarities in responses with the data attained through other data sources such as observations, field notes, and archival files.

Informed Consent

Each of the four TCU sites selected was contacted to determine their Institutional Review Board (IRB) requirements for inclusion into this study. All required IRB

stipulations were followed. The president of each selected TCU authorized the use of each respective campus and was willing to be the initial contact. The purpose of this contact was to explain the research, case study process, and function of the data collected. With the president's permission and referral, other staff and faculty were contacted as primary participants. Prior to the interviews, each participant was asked to sign a consent form acknowledging that the information collected would be used in this study, but that identities would be kept confidential. These individuals were provided with contact information for any unanswered concerns, questions, or to withdraw from the study at any time.

Data Collection

Prior to commencing the research study, an interview guide was developed to capture context, content, and thoughts pertaining to technology transfer and how it relates to TCUs. The development of the interview guide is part of the logic behind linking the research questions with data collection and analysis to ensure reliability and validity (Ponelis, 2015). In addition, a field study was conducted to assist with validating the interview questionnaire. This field study was done using a volunteer faculty and an administrator from Institution D and the faculty participant's survey was included as part of the main study. The feedback and responses received through the field study allowed for a limited number of questionnaire modifications (Cooper & Schindler, 2008).

The data collected consisted of answers to interview questions, comprehensive review of institutional reports, and field notes exploring the level of undergraduate research, organizational leadership, and technology transfer activities at participating TCUs. The data collection instrument was an open-ended style questionnaire.

Additionally, in-depth, on-site, face-to-face interviews were conducted with each participant using this open-ended format. According to Anderman and Anderman (2009) in-depth open-ended interviews have been proven to provide quality information about participants' experiences and personal perspectives. The interviews were recorded and transcribed by the researcher. The transcription of each interview was sent to each interviewee for review and verification that their statements were accurate and reflected exactly what they intended to convey. The process of verifying the transcription for accuracy is to ensure this component of data analysis was valid and reliably. According to Ponelis (2015), to eliminate misunderstandings and add credibility to the research, confirmation of accurate transcription is essential for validity and reliability of the research.

Validity and Reliability

To enhance the validity and reliability of the findings, the following three components were used as part of the triangulation procedure. First, open ended interview results were the initial data gathering technique. Second, a thorough investigation of organizational reports, newsletters, websites, etc. was completed. Third, field notes based on observations from site visits and additional comments by site staff and faculty were gathered. Furthermore, to gain deeper understandings of the data collected and reinforce validity and reliability of the research, findings from all sources are cluster together and analyzed and reviewed against the literature (Ponelis, 2015). According to Marshall and Rossman (2011) and Tellis (1997) such technique establishes creditability and transferability of results to other research studies. In addition, accuracy of data is elevated to improve reliability of research study results (Yin, 1994). As stated in the

literature review, Native Americans tend to view interviews as a story telling method. This research project allowed for the creation of a story about technology transfer and how it relates to the individuals and organizational culture at the four TCUs. The case study approach presents a holistic portrayal of the persons or programs under study (Cope, 2005).

Internal Validity. The use of multiple sources may present issues about validity or the ability to develop themes in a case study (Tellis, 1997). The development of rich descriptions around themes increases dependability of case study results (Ponelis, 2015). Bias within a case study that involves in-person interviews is the largest threat to this approach of data collection (Bromley, 1990). The process of developing messy and disjointed transcripts into coherent and manageable themes to create a more manageable synopsis by utilizing a sound case study approach helps add credibility (Ponelis, 2015). The utilization of triangulation in the research study design helped minimize issues of internal validity (Marshall & Rossman, 2011; Tellis, 1997; Yin, 2012). Together with archival report data, and field note comparisons, the use of verified interview transcription data helped ensure confirmation of alignment across themes.

External Validity. Yin (1994) stated that external validity is achieved through the generalization of study results to different circumstances. In addition, Miles and Huberman (2013) stated that selection of study participants and study locations are two of the most common threats to external validity. The ability to apply study findings to other situations that are similar increases transferability, and thus improves external validity (Ponelis, 2015). In an effort to minimize stated threats, the participating TCU's were varied in size and location. Four distinct geographic locations throughout the United

States where used to select the four TCUs. In addition, the selected TCUs had enrollments ranging from 380 to 2,300 full-time students at the time of the study. The respondents were limited to administrators, faculty, and staff with potentially relevant technology transfer experience or information.

Reliability. According to Cooper and Schindler (2013) the consistency of the approach within a research study that can be repeated in other studies determines the level of reliability. Reliability and dependability is tied to the quality of data gathered and the analysis of such data with direct relationship to the purpose of the study (Ponelis, 2015). Tellis (1997) also emphasizes the ethical need to ensure reliability through triangulation. The three data collection methods in this case study used interviews, archival records, and field notes taken at each site. This multiple site case study had defined boundaries (Miles & Huberman, 2013) and utilized triangulation to increase the reliability of research results. According to Ponelis (2015) using multiple sources of data is a preferred triangulation method that allows for the emergence of significant insights that are reliable.

Data Analysis

Data analysis process involved tools contained within NVivo10®. NVivo10® is a qualitative data analysis package created to help organize and analyze unstructured data (Richards, 2002). According to Cooper and Schindler (2008) after collecting and organizing the data from a research study, the next step is to condense and code raw data to determine themes. Once the data was collected via interviews with TCU respondents, the transcriptions were sent for review by the participants and then imported into NVivo10®. The digital files underwent accurate transcription that included multiple

reviews. The data was then reviewed and coded for emerging themes and subthemes. These were further analyzed and distilled into themes specific to technology transfer issues described in more detail in chapter 4. In accordance with the methodology's purpose, these findings were considered exploratory and combined with other data elements before conclusions were drawn. The additional data elements gathered and later analyzed were university archival files, field notes, and personal observations. In case study research, detailed descriptions of certain topic areas may come to the forefront from various participants' responses (Marshall & Rossman, 2011; Yin, 2012). The ability to capture contextual information about each participant and their institution lead to a better understanding of the cultural factors that influence technology transfers at TCUs.

Chapter 3 Summary

The purpose of this study was to gather relevant information through the utilization of the multiple site case study approach that involved open-ended interview questions, archival data, and field notes. The goal of this study was to identify areas of concern within a sample of TCUs and see how these affect technology transfers for TCUs. Through the onsite interview questionnaires, relevant institutional reports, and researcher field notes, data analysis was conducted and themes were developed and compared to the research questions. The use of a multiple site case study was to capture the issues and other relevant data to address the research questions.

Chapters 1, 2, and 3 contained the basis for this study as well as the method and approach. The ramifications of the study were clear based on the roles of researcher and the tasks involved in the research study. Chapter 4 provides insight into the research study data collection and analysis.

Chapter 4

Analysis and Results

This chapter presents the results of twenty face-to-face interviews with faculty, researchers, and administrators, along with details from archival data and field notes, from the four pre-selected Tribal Colleges and Universities (TCUs). Chapter 4 includes insight into the initial field study interview used to validate the study instrument and the minor modifications made. The focus of this qualitative multiple site exploratory case study was to identify the factors that affect technology transfer at the selected TCUs. An on-site interview protocol provided the framework for conducting the on-site interviews using a predetermined set of questions. Several participants took the opportunity to supply additional pieces of information that they felt were relevant to the discussion. The interviews were recorded and transcribed into electronic form, validated by participants, then analyzed using NVivo10® software to code emerging themes. Observations and notes during site visits were cross-referenced, along with archival data, such as annual reports, strategic plans, and other institutional documents to substantiate the findings. In addition, information obtained from a review of the literature was compared with the study results. Chapter 4 concludes with a summarization of research design, data analysis, reliability, and validity of the findings.

Field Study

A field study was conducted at the start of the data collection efforts. The field study assisted with validation of the interview questions and interview procedure. Interviews were conducted with a Ph.D. faculty member with numerous years of teaching and research experience and an administrator at Institution D. Upon conclusion of the

field study interview, feedback was obtained for each question in terms of clarity, question sequence, and overall interview format. After review of feedback it was determined that no major changes were needed, only slight clarifications to two questions were made. Additional clarification on question three resulted in the addition of "…that is related to any research or product development…". On question eight, the term "interests" was changed to "capabilities." The minor modifications to the on-site interview questionnaire did not require a change to the main research question or research methodology. The responses from the field study faculty participant were ultimately used as part of the main study results. The main study was conducted using the slightly updated interview instrument.

Sample Demographics

Participants of the study were selected by purposive sampling of TCU employees. Purposeful sampling is used to target information-rich sources that can provide deep insight into the central issues of importance concerning the study (Cope, 2005). No personal demographic information was required. The 20 person sample included three TCU presidents, three vice presidents, three deans, and 11 instructors from the four pre-determined TCUs. The institutions in the study were also based upon purposive sampling as stated in chapter 3.

Data Analysis and Interpretation

The analysis of the data collected in the study involved four distinct levels. These levels were based upon a study conducted by Cope (2005). Cope (2005) contends that these four levels encompass full transcription of interviews and initial analysis, level one; compilation of study participant data to develop a case study narrative, level two; cross-

case comparison; level three; and concluding with level four, confirming how the themes were developed and validated.

Level one involved accurately transcribing each interview recording. The transcriptions were sent to each participant and they were instructed to review their responses for accuracy. A follow-up verification of the transcription was obtained from each study participant. All participants confirmed the accuracy of their transcription without changes. This procedure was done to ensure accuracy and increase validity of the study.

Level two involved the analysis of the text version of the interviews into various codes and themes. Cope (2005) affirms that this process allows seemingly disjointed data to begin to form a more coherent synopsis. All finalized transcriptions were imported into NVivo10® qualitative research software. NVivo10® aids in the organization of research material and provides several tools for generating data driven coding ideas. This allowed for word frequencies, clouds, and trees to be generated from participant responses, which were reviewed prior to initial coding. Coding involved assigning key words, or codes, to represent each idea or concept the respondent seemed to convey. Each transcription was reviewed in the order in which the interview was obtained. The initial pre-set codes were technology transfer barriers and resources. These were based on the purpose of the study. Level two provided a strong information base from which deeper insights can be drawn.

Level three further refined the emerging themes with archival data and field notes. The development of general and unique themes is important so that additional data sources can be checked against reliable outcomes (Cope, 2005). Emergent codes were

further developed during this process. A second iteration through the transcripts was conducted to ensure the new codes were applied to all responses. The codes were further refined to fit the data. Some codes were split into sub-codes while others were collapsed into a broader category. Research notes concerning code changes and emerging ideas were written and reviewed as part of the coding process. Ultimately the initial case study narrative was developed and the themes and subthemes were taken to the next level.

Level four took the analysis to a deeper level of understanding by confirming the emergent relationships around the themes and across the three data sources. The archival data investigated was reviewed against the themes to check for validity and increase reliability of the study. For instance, at Institution B, their current strategic plan includes a goal to foster relationships with community and industry; however, no specifics were provided, this supports the optimism theme, as well as the themes of technology transfer strategy and remoteness of institution. In addition, their plan mentions the support of regional economic development through a business incubator, but again, no details on exactly how this is to be implemented. Field notes were reviewed in a similar fashion to also check for validity and reliability. During the visit to Institution C, the administrative team was busy preparing for an accreditation team visit and most of the conversations were associated with academics and related issues. Research and technology transfer was not part of the topics of discussion. This supports the theme of institutional core mission of academics, time constraints, and institutional research capabilities. After completion of this final level, themes were determined to be creditable and consistent in the study.

The design of the research questions used in the on-site interview was to solicit thoughts around technology transfer and categorize them into general themes. The

interview questions allowed study participants to freely express their thoughts about each topic brought forth. Not all questions pertained to each participant, given the background, skills, and current job responsibilities; however, most study participants did have thoughts and opinions concerning each topic. All interview questions were developed to address the research questions and gain insight into the phenomena in question. Participants began the interview by answering the initial question about their knowledge of patents, copyrights, and the protection of intellectual property. Other interview questions lead to information on the amount of time devoted towards research, instruction, or administrative duties. Additionally, answers were also centered on local economic development; connections with other organizations; research capabilities; institutional policy; institutional research focus areas; and technology transfer. The interview questionnaire is in Appendix B.

The interview data was compared to information found in the archival data, which included annual reports, research grant findings, strategic planning documents, newsletters, employee handbooks, and websites from each participating institution. This triangulation process, according to Farmer, Robinson, Elliott, and Eyles (2006) is to primarily explore convergence, complementarity, and dissonance. In other words, where does the data come together, where does it complement each other, and where is there disagreement. The triangular process occurred during the data analysis and the development of each theme.

Themes

The NVivo10® software assisted with organizing answers and grouping the frequency of occurrences of key words and statements from the transcribed interviews of

the participants. Similar responses were matched up and assigned a theme. A review of key word frequencies that emerged from the analysis of all the transcripts resulted in the development of themes. In supporting the development of the themes, information gathered from archival data and field notes supported this process. The following five themes emerged from the interview, archival, and field note data: Barriers, Optimism, Technology Transfer Strategy, Lack of knowledge about Technology Transfer, and Institutional Research Capabilities. Under Barriers, several subthemes also emerged, which are: Time Constraints, Lack of Administrative Support, Institutional Research Capabilities, Individual Research Capabilities, Remoteness of Institution, and Institutional Core Mission of Academics.

Barriers: Time Constraints

When asked *"How much of your time is devoted to research? What percentage of your time at this TCU is for classroom instruction, administration, or other duties?"* all 11 faculty participants cited lack of time as a major factor in keeping them from conducting more and better research. In exploring the class schedules of each institution, the teaching loads for most of the faculty participants consumed most of each day of the week. In addition, from reviewing interview notes, it was a difficult process to schedule time to conduct the interview, and in most cases, it took the entire day and in two cases, into the evening to complete all five interviews at each institution. However, also in my field notes, I noted each participant's interest in technology transfer and 18 out of 20 said they were interested in the topic and were optimistic about the benefits to their institution.

Participant 2 reiterates a common argument among TCUs faculty, that most TCU faculty undertake a lot more duties than a typical mainstream institution. This person

states “I would like to be able to devote half my time with my research, but realistically I can only dedicate about 10% or so, half my time is teaching and the other half administrative, grants, reports, college stuff.” Participant 15 states “Not as much as I would like [research], I can devote about a quarter of time towards research, half the time in teaching and the rest is administrative.” The time issue is also present in the responses from the administrators when asked the same question. Participant 19 says, “All of my time is consumed with administrative duties, but again I strongly support research and feel it is good for students and faculty to be involved and look towards innovation and maybe someday we can get to a point that technology transfer is part of our institution.” In institution A’s 2014-15 Annual Report, it states, “…institutions have an obligation to apply their limited resources where they are needed most in order to meet their mission and balance the budget. Especially today, colleges and universities everywhere are taking a look at their program array and trying to see how they can use their curriculum and their faculty and staff talent most effectively.” The report continues on to state that teaching, administration, and student support duties take up the majority of time for staff, whereas it mentions some faculty engage in research.

Barriers: Lack of Administrative Support

It was evident that academics was a priority for the four institutions involved in this study and the faculty received support for teaching and learning; however, when research became part of STEM curriculum the support from administration was cautious. At Institution C, participant 14 expressed disappointment in the amount of money spent on STEM research, including labs, equipment, and faculty professional development, he also felt the funds could have been better spent to improved vocational programs with

better results for students. He continues on to state that STEM jobs are few on the reservation; we need more teachers, social workers, and nurses. Participant 10 states "Although administration likes the grant money I bring in, they don't really allow us the time to truly conduct an in-depth research project." The annual report of Institution C states the mission of the college is to concentrate efforts towards local employment needs and native language, culture, and traditions, supporting the lack of support from the top leaders and stakeholders of that institution.

At Institution D, there is evidence that research receives more support from administration then the other three participating institutions. Participant 1reported that with the increase in undergraduate research, more evidence is out there demonstrating its effectiveness in keeping students in STEM and giving students more experience for when they go out into the job market. Participant 1 goes on the state that when he started to have a rather large group of students involved in research projects, some administrators did view this as a way to get out of teaching; however, as time went by, administration slowly began to realize the benefits of research and now are starting to embrace the efforts. More undergraduate research is also expanding across STEM disciplines at Institution B, where Participant 6 discussed how it wasn't until some new administrators were hired that STEM became a focus of their institution. Before that, it was nearly impossible to get approval to write a grant to fund undergraduate research. He goes on to say "He kind of laid the groundwork, the direction that we needed to pursue, so then from there we reached out to other entities…" Similar to Institution D, it took several years for buy-in from a majority of the top administrators to see the benefits of research, specifically in the STEM disciplines.

Barriers: Institutional Research Capabilities

Several participants cited inadequate, outdated, or broken research equipment as a major hindrance to conducting high level research. From a review of project reports and annual reports, the four participating institutions had a combined $17,494,314 in grants that contained a research component in STEM. The number enrolled in all STEM programs at these four institutions for the academic year 2013-14 was 463 students. Having so few numbers means it is difficult to justify spending large sums of money on equipment that is only used by a handful of students, states Participant 12. Participant 11 supports this statement by saying "I understand it is difficult to obtain equipment money for some of these undergraduate research projects, as we frankly do not have the numbers in the STEM degree programs. We have good students and great faculty, just low numbers."

When participants were asked *How many full-time Ph.D. faculty members in STEM are at your institution?* I received various answers off the top of their heads. Upon reviewing institutional documents, for the most part, the participants were in the ballpark on their estimates. Participant 1 had this to say "I guess the only other thing I would add on this topic is that it's not necessarily a reliable predictor on who's going to produce this technology that could be transferred in or out." Participant 13 adds, "We have several, but not sure how many are in STEM, I don't have a Ph.D., but am plenty capable of conducting research that may be technology transfer quality and I think it all depends upon the issue being researched or developed." In a review of the field notes, the majority of the STEM Ph.D. faculty across all four institutions appears to be just

beginning their careers in academia and was eager to teach students and engage them in research.

Barriers: Individual Research Capabilities

The capabilities of individual researchers as a barrier were primarily focused upon the loss of expertise and not keeping up with the latest within their field of study. The question posed to the participants was: *How would you describe your research capabilities?* Participant 2 states that he has "…done high-level research in the past and hopefully will be able to get back in the lab and explore some ideas that I am developing." Participant 4 provides some more detail:

> I would like to a lot more, since getting my PhD I haven't done much research but again I would like to get more into it. Been busy with grants, writing curriculum, finding funding for students. I got this cool piece of equipment that measures photosynthesis about three years ago that came in three boxes and six instruction manuals, and I haven't had the time to learn about its capabilities or design some research using it.

Participant 10 states "I feel I am pretty good, but like I said, I am not in the lab as much as I used to be, so maybe my skills are behind and need to be brought up to speed." And then Participant 16 has this to say: **"**I wouldn't say I was an expert and anything like that, but I can and have done some pretty cutting edge research, but as with anything if you don't use it you may lose it, so such is the case with me. I need to do some more research to keep my skills up and maybe get into the latest trends of research."

The review of credentials of faculty interview participants supports the suggestion that the STEM faculty have the qualifications to conduct leading edge research. In a

review of faculty handbooks, support for professional development is found in all four; however, very little evidence was found in reports that indicated time and resources were allocated for STEM researchers to continue to improve or expand their skill set.

Barriers: Remoteness of Institution

As stated in previous chapters, a majority of TCUs are located within Indian Reservations that are considered rural. This remoteness is reflected in some of the responses from the participants and cited in several institutional reports. Participant 12 reports that "…we are so remote there are not many options in this area." This participant was referring to the question about connections with other institutions, organizations or industry. Three out of the four institutions had faculty regularly compute 70 miles or more one way to teach class or lead research projects, according to field notes. This type of barrier can also be related to time constrains of faculty, as two hours or more a day is consumed by travel.

Institution C mentions 54 organizations which donated towards institutional efforts, with nine of them corporations and the rest foundations. Participant 14 at this institution stated that most of these donations where for academic program support, scholarships, and building their endowment. It is difficult for major corporations to make significant investments in institutions that are difficult to visit. According to Participant 6, there have been efforts in the past to bring TCUs and corporations, primarily in the technology fields together and discuss methods to collaborate at higher levels. This effort faded away, as both the TCUs and corporations expended time and resources with little to show for it, says Participant 6. Participant 14 was also part of this endeavor and couldn't recall anything positive that came from the multiple gatherings.

Barriers: Institutional Core Mission of Academics

In a review of each of the four institutions' annual reports, each mission statement refers to a commitment to the local culture and community. Three did have research mentioned as a way to support the vision of the institution. But, the overall impression of the mission and vision of each institution is one of serving local employment, culture, and native language needs. From field notes, the majority of jobs in the communities appear to be in education, health care, agriculture, and in the service industry. Participant 17 states that their institution is interested in research but reiterates they "…are primarily a teaching college, rather than a research institution, but can and will support wherever we can. Tribal colleges are different than a mainstream institution, and this is where you may run into issues around your topic, as tribal colleges have tribal councils to deal with and educating them about new and innovative ideas or research is a large job." Participant 14 goes on to say "…we are concerned with educating our students and giving them the education and training they need to seek meaningful employment."

Optimism

One area that demonstrates optimism and the desire to learn more about technology transfer is when I asked, "Is your institution interested or involved with local economic development?" a majority of the participants expressed interest in how it can fit in with what they are doing now. Participant 9 strongly supports local economic development and states "…in the area of technology transfer we hope to do more on this, not knowing as much as it appears I should; I will definitely research more in this area." With more faculty and more STEM programs, Participant 1 believes there is a positive trend towards potentially participating in technology transfer in some fashion in the near future.

Participant 3 relays a positive approach in regard to local economic development. "Even though I am considered an outsider by the tribal people locally, I still believe they view me as a resource that can provide some sort of opportunity in the hi-tech world and provide high paying jobs around here." Participant 19 states "We have some bright people working here with lots of great ideas, so I constantly check with different tribal departments to see how we can help." "We are encouraged and progressing and I think more and more opportunities will present themselves…" Participant 6 adds. When asked about if the participant had an entrepreneurial spirit, Participant 12 responses, "I do, I am all for economic development and the expansion of business opportunities here on the reservation." At some point over the last 10 years, evidence of business incubators, or economic development offices were operating at each of the four participating institutions. This evidence was found in archived newsletters, annual reports, and informal discussions with administrators, faculty, and staff.

Technology Transfer Strategy

When I explained what technology transfer is and gave some examples of how some universities have benefited from the process, many participants were intrigued by the concept. Participant 1 mentions that his institution has a pretty sophisticated science program and that "…with the tribes blessing could be looking at medicinal plants that could have real commercial value out in the marketplace." Participant 9 states "We want to look at technology transfer at other universities and see how they work…" she continues on to name some potential partners in the process. Participant 3 was the only person to have their name on a patent and was involved in the technology transfer process at a previous institution she worked at and continues to receive royalties from the

licensing of their invention. Participant 6 has attended workshops and visited the technology transfer office at a state institution in which they work closely with on different projects. He goes on to state "…we talked about possibilities and some of the things we could pursue right off hand and patents and trademarks came into play right away because of the uniqueness of us being a tribal college offers those opportunities, as there has been missed opportunities…" Participant 6 continues on about how there were not only missed opportunities for his institution but his tribe in general. He could not provide specifics, but after reviewing archived annual reports, several partnerships with organizations were highlighted over the years, but there is no evidence of them currently. At Institution A, a review of the policy and procedure manual discusses copyright and intellectual property, but in the context of textbooks and academic content knowledge.

Lack of knowledge about Technology Transfer

When Participant 17 was asked about the role of the institution in local economic developed, she responded with the idea their tribal chairman was interested in pursuing it and about having the college conduct further research on the product as well as conduct market research. Participant 6 provides comment on how a company has partnered with their institution on a project and now a team is looking into how to develop the product idea. He goes on to state that because they have a non-disclosure with this company, he is not sure how this may work and how much he can reveal in the interview.

Technology transfer was often confused with general business entrepreneurship and business development that involves local retail-type sales. Participant 9 was involved with the institutions efforts to develop an entrepreneurial center that would provide support for new business start-ups and existing business expansions. She was

intrigued about the possibilities with technology transfer, but had difficulty connecting all the different processes that were involved. Participant 18 was also involved with his institutions business incubator and was also interested in how technology transfer could be part of the efforts, but expressed skepticism they could implement it. A review of both centers' websites reveal more localized efforts and little focus upon developing ideas generated through cutting edge research.

Institutional Research Capabilities

Along the lines of individual concern with research capabilities, the capabilities institution-wide was also a concern of several participants of the study. Participant 12 states that their institution has some state-of-the-art pieces of equipment to conduct research, but there is little time to receive proper training to effectively and efficiently run the machines. Participant 11 points out that it is difficult to plan research projects consistently that rely on having students be at a certain level. With having varying number of students each semester or quarter with such a wide range of skills, TCUs have a difficult time conducting research at a constant level.

At each site visit, a campus tour was made and each institution displayed their research laboratories and touted their capabilities. One institution was heavily involved in 3D scanning and printing and was excited about partnering with outside entities for research and product development; however, Participant 10 reluctantly acknowledge their equipment was probably too much on the low end of the spectrum to do high end research. Another institution is involved with forestry and has research equipment that was obtained through government surplus, but Participant 4 had to admit that he or others

in the department was not trained on how to use it and the equipment may have become outdated.

Outliers

One area of particular interest was the lack of discussion on how the Native American culture may be influencing research and technology transfer in a negative way. The little discussion around culture was from Participant 9 who discussed how currently there is not an organized procedure to protect their indigenous knowledge or plants from a large corporation that may want to utilize this knowledge or plant for commercial purposes. She goes on to state that maybe her new department may be responsible to develop some protection of culturally important knowledge and plants.

Another area of interest is the lack of discussion about graduate students and its possible affect upon the level of research at TCUs. As mentioned earlier, there is a severe lack of STEM graduate students conducting research at TCUs; however, none of the study participants mentioned this as a barrier to technology transfer. Perhaps this is related to the lack of understanding of exactly how technology transfer is occurring at other, larger institutions.

Chapter 4 Summary

Chapter 4 presented the findings resulting from a triangulation of data collected by interviews, archival data, and field notes that explored insight into technology transfer, potential barriers, possible opportunities, and an optimistic view of what may be possible for TCUs in the future. Chapter 4 began with a discussion of the field study, demographics of the study participants, responses of participants, related archival data, field notes; all synthesized into major themes. The interviews captured factors that may

inhibit or encourage technology transfer, the additional data, in the forms of annual reports, institutional catalogs, federal grant reports, and interviewer field notes, among others to provided supporting facts from a different angle.

There were five main themes that emerged from participants' responses to the interview questions came from analysis through the NVivo10® software. In addition, similar findings from archival data and field notes mapped up to support the themes. The five main themes derived from the data were: Barriers, Optimism, Technology Transfer Strategy, Lack of knowledge about Technology Transfer, and Institutional Research Capabilities. Under Barriers, there were six subthemes: Time Constraints, Lack of Administrative Support, Institutional Research Capabilities, Individual Research Capabilities, Remoteness of Institution, and Institutional Core Mission of Academics.

The study results demonstrates that although there is a tremendous amount of optimism in regard to technology transfer, the data shows there are several barriers to fully implement a technology transfer process at any of the participating TCUs in the study. In general, the faculty participants cited lack of time, resources, and research focus that may lead to any sort of technology transfer. The shortcomings were supported by the review of archival data and field notes. The administration-level participants cited financial constraints, academic focus, remoteness, and unclear benefits that technology transfer may bring to their institution. Participants cited most of the research conducted was directly related to local issues, mainly environmental. This is supported by the review of institutional annual reports, grant annual reports, and newsletters that highlight the research into local issues that are primarily focused upon water, forest, and land issues.

In general, most participants believed technology transfer could be possible at some future point, but most couldn't describe how this could be achieved. The participants cited the teaching and basic research skill building as the focus of their STEM programs. In addition, participants mention that more advanced research is conducted in summer programs at larger universities or national laboratories. The majority of the participants provided similar responses to the interview questions with slight variations depending upon their position at the institution. The information gathered from annual reports and other institutional documents cite funding priorities to be in the delivery of courses that support the base needs of students. Most funding for research is obtained from grants, usually through a federal agency, such as the National Science Foundation, or the National Institute of Health. Chapter 5 provides conclusions, recommendations, and an interpretation of study results detailed in Chapter 4.

Chapter 5

Conclusions and Recommendations

The lack of knowledge and understanding in the area of technology transfer and Tribal Colleges and Universities required further investigation. This study provided insight and new knowledge in the lack of understanding and involvement of Tribal Colleges and Universities (TCUs) in the area of technology transfer from the perspectives of twenty TCU presidents, administrators, researchers, and instructors. The purpose of this qualitative exploratory multiple site case study was to identify the factors that may have an effect on technology transfer at the selected TCUs.

The following main research question guided the study: What are the factors that affect technology transfer at Tribal Colleges and Universities? Secondary research questions addressed more specific factors and sought to gain a better understanding of potential issues, they were: 1. What pieces of information are lacking about technology transfer at TCUs? 2. What are the factors that influence technology transfer at TCUs? 3. How does undergraduate research impact technology transfer at TCUs?

A qualitative exploratory case study design utilizing multiple sites provided the data for the study. The data was collected through a triangulation process with on-site interviews, archival data, and field notes. The approach provided insight into the thoughts and ideas of key stakeholders at the participating TCUs, along with evidence gathered from archival data, validated with field notes and transcriptions. An on-site interview questionnaire consisting of predetermined questions allowed participants to explain their views and insights regarding the problem under study. NVivo10® software was used to code and organize participant responses into themes. Archival data provided

historical information about the institutions mission, vision, goals, objectives, research interests, financial position, students, faculty, and other bits of information to assist with addressing the research questions. Field notes on each participant aided in recalling the participants' reactions to each particular question during each of the interviews, along with observations about each institution.

Chapter 5 summarizes the conclusions and recommendations resulting from this qualitative exploratory multiple site case study. This chapter presents a discussion of the findings and interpretations of the conclusions drawn from the analysis of the data. Chapter 5 concludes the study results with implications, recommendations for TCU leaders, research study reflections, recommendations for future research, and a summary.

Conclusions

This study explored the issues that are affecting technology transfer at Tribal Colleges and Universities (TCUs) using face-to-face interviews, archival data, and field notes. Twenty participants, five each from four TCUs were part of the study. Five main themes were developed from the study: Barriers, Optimism, Technology Transfer Strategy, Lack of knowledge about Technology Transfer, and Institutional Research Capabilities. Under Barriers, there were six subthemes: Time Constraints, Lack of Administrative Support, Institutional Research Capabilities, Individual Research Capabilities, Remoteness of Institution, and Institutional Core Mission of Academics.

Theme 1A: Barriers – Time Constraints

Participants believed that the amount of time available to conduct high level research that could lead to a technology transfer situation was a major inhibitor. According to Vance (2010) most TCU faculty report a severe lack of time to conduct

research and also the issue of not publishing in peer reviewed journals. TCU administrators felt a faculty person's time should be devoted towards teaching and student support. TCU faculty expressed the need for time to conduct research with students, but these projects tended to be on issues important to the local community, such as water quality and other natural resource issues. Other time constraints included faculty time to participate in campus activities, events, mentoring, comminuting, and other student related instructional issues.

Theme 1B: Barriers – Lack of Administrative Support

Study participants indicated that support from senior administration was mixed. On one hand, TCU administration enjoyed the grant funding that came to their institution to conduct research, but administration was reluctant to allow sufficient time away from the classroom to conduct the actual research projects. The level of research was found to be basic in nature with most projects based upon issues that affected things locally. When research is centered on local areas of interest, the majority research community often invalidates the results (Cummins et al., 2010; Zaffos, 2013). The cost to maintain and update research equipment after grant funds were expired was an issue with administration, along with the constant struggle for general funding, adequate buildings, and staff turnover, according to Voorhees (2004). Although, in most institutional reports, research is part of the focus, a majority of the efforts seem to center upon meeting the basic educational needs of the students.

Theme 1C: Barriers – Institutional Research Capabilities

The level of research found at the four participating institutions ranged from students observing and journaling on field trips, to helping build a satellite that was

launched by NASA. The inconsistent level of funding, predominantly federal grant funding has lead to wide disparities in STEM research. Most faculty participants discussed the large amount of time devoted towards grant writing and reporting as a hindrance to trying to secure larger research grant funding. Senior administrator participants touched upon this area by stressing the basic educational needs of their institutions take precedence over STEM research projects. Pekow (2007) states TCU presidents and other high level administrators continually lobby congress for funds to keep the doors open. A review of annual reports support the fact that research is primarily focused upon giving students experience and supporting faculty salaries rather than enhancing and expanding research capabilities for the institution.

Theme 1D: Barriers – Individual Research Capabilities

While most faculty participants felt confident in their research capabilities, a majority of them feared they were falling behind their peers because of the lack of time to improve their skills. Although the faculty in this study indicated they have been at their current position for several years, Voorhees (2004) found that TCU faculty were likely to have less experience, hold a master's degree or less, and continue to review positions outside of their current institution.

All reports under review found little evidence of professional development and little focus upon improving faculty research capabilities. Also, there was little found about training on any new equipment that was purchased through grants or obtained through government surplus. In some cases; however, reports indicated that there are some organizations assisting faculty with professional development through regional workshops, but these offerings were inconsistent.

Theme 1E: Barriers – Remoteness of Institution

Most TCUs in the nation are located on or near an Indian Reservation, and most Indian Reservations are found in remote and rural areas of the country. Technology transfer can happen in any environment; however, connections need to be established, and introductions made. According to Bertrand (2010), a commitment of time and resources is needed to support innovation. Given the stated financial and time constraints of the TCUs in the study, this makes traveling and meeting potential partners very difficult. In addition, the remoteness also makes it difficult for potential collaborators to visit the TCU campuses.

The remoteness of TCUs makes it difficult to justify the costs for companies that do want to partner with a TCU on projects. There is interest, and based upon information found in reports, connections have been established, but efforts appear to diminish over time as costs versus benefit becomes a factor, according to leadership. Based upon findings in documents, it appears it is enough to just make the effort for a majority of the companies to satisfy stakeholders.

Theme 1F: Barriers – Institutional Core Mission of Academics

Although each TCU has unique and specific institutional visions and missions, generally they were established to meet the basic educational needs of individuals within the communities in which they serve. Because for the most part, local employment opportunities are limited and jobs in innovative research areas are rare within these communities, most academic programs are geared towards environmental science, business, education, and health care. Most administrators agree that meeting the local

employment needs take greater precedence then supporting innovative research that could lead to technology transfer.

In most reports, flyers, newsletters, impacts to the local community are highlighted and any research results that may have larger, broader affects are not as prominently displayed. Most students that attend TCUs are from the local communities that often times have to take remedial courses to get "college ready", and most of these students do not have the opportunity or ability to travel across the country or internationally. With such a local perspective and low academic performance, it is difficult for researchers and administration to promote research that may have impacts beyond the reservation. According to Hawkins (2011) a majority of incoming freshmen at a particular TCU had to enroll in remedial reading, writing, and math courses, which causes faculty to take time away from research to teach basic skills that the student should have learned in high school.

Theme 2: Optimism

The optimistic view that came out of the study was centered on local economic development. According to Crazy Bull (2004), tribal researchers must conduct research that seeks to address community issues; however, to incorporate technology transfer into local economic development efforts that can deal with community concerns needs to be further investigated. Still, the amount of enthusiasm about the potential of technology transfer can be a driving force in the area of economic development.

Theme 3: Technology Transfer Strategy

The idea of technology transfer and how TCUs can participate in the process created excitement and enthusiasm about the possibilities and opportunities. Participants

pointed out the quality of their STEM programs that include research as part of the curriculum and the type of research that was being conducted. Some participants pointed out their past involvement with technology transfer at other institutions and how it could be possibly implemented at their TCU. The majority of the study participants felt the need to develop a strategy to not only explore the potential benefits but also the potential drawbacks to technology transfer.

Theme 4: Lack of knowledge about Technology Transfer

The lack of understanding exactly how technology transfer is conducted at a college or university is not necessarily a negative, as the level of optimism about the idea is high among study participants, but exactly how technology transfer can occur is unclear for most participants. In the North Dakota tribal college faculty research model, Davis, Givers, and Johnson (2007) present a detailed and well thought out model for TCUs to conduct research, but there is no discussion about whether or not study results may have technology transfer applications. All participating institutions had connections with outside organizations at some level on research projects or economic development and two even had no-disclosure statements in place. But, the collaborations do not appear to be moving towards potential technology transfer.

Theme 5: Institutional Research Capabilities

Tribal college and university research capabilities are a combination of faculty, students, and equipment, not unlike any other institution. The consistency and level of research directly affects the institutions capabilities when it comes to technology transfer. Faculty researchers need to be fully trained on equipment, techniques, and protocol to conduct high level research. Students need to be well prepared in research skills and

have the proper foundation in math and science to conduct high level research. The research equipment needs to be at a level to properly carry out the planned research, as well as be in good condition. According to Corbyn (2011) the increase in the level of research at TCUs is good, but that the research quality in addition to the basic level of research needs to be improved. Although all participating institutions in the study appeared to have these capabilities in place, not all study participants felt their institution had to capability to carry out research that would lead to technology transfer.

Implications

The study resulted in five themes and several sub-themes deemed to have considerable influence on the technology transfer at tribal colleges and universities. The five themes are Barriers, Optimism, Technology Transfer Strategy, Lack of knowledge about Technology Transfer, and Institutional Research Capabilities. Under Barriers, the subthemes are Time Constraints, Lack of Administrative Support, Institutional Research Capabilities, Individual Research Capabilities, Remoteness of Institution, and Institutional Core Mission of Academics.

The themes in this study were derived from the review of study participants' views and perceptions on technology transfer and how their institution either supported or hindered the process. The use of archival data and field notes gathered and integrated with interview data validated the results and provided additional reliability in the study. Tribal colleges and universities may benefit from the findings of this study through revising research policy, exploring how technology transfer may work within their institutional goals and objectives, or look to monitor the effects upon other TCUs that may begin to develop technology transfer processes. New and developing ideas about

technology transfer and its benefits or risks will be of value to administrators, faculty, students, and all stakeholders in the TCU community.

Recommendations for Leaders

The findings of this study have several areas that should be important to TCU administrative teams, tribal communities, and society in general. The list of barriers facing research faculty are many and TCU leadership will need to seek solutions if they are to pursue technology transfer at their institution. The numerous models out in the academic world highlighting methods that work to some degree in larger institutions require time and effort that a typical TCU may not be able to afford. To foster innovation between industry and academia, constant communications is required (Krucken et al., 2007). Tribal college and university leaders will need to explore how the tribal college faculty research model may affect technology transfer efforts. According to Davis et al. (2007) Western research ideas and methods and Native science need to be interconnected and through this melding, technology transfer efforts could develop in this interrelated world of STEM research.

The purpose of recommendations is to institute change in how TCU leadership views technology transfer and instill possible solutions to the barriers found at the participating TCUs. Understanding the issues and potential benefits may lead to the development of deeper relationships with industry and business partners on technology transfer projects. For the stakeholders, advancing research to the point of creating technology that may be transferred into the marketplace can have more positive impact then the potential monetary return. Students and the local community may feel an

increased sense of pride and respect for the TCU, along with an excitement around STEM research and the positive results that may occur.

Recommendations for Action

Based on the findings in the qualitative exploratory multiple site case study, the following recommendations may assist in efforts to seek solutions to the barriers found by TCUs that are hindering the technology transfer process. Leadership at TCUs should seek feedback from STEM faculty to review how technology transfer can be integrated into the mission, vision, and goals of the institution. TCUs should look to establishing a team to overcome the barriers, establish relationships with potential partners, and reach out to other TCUs on what issues they may be facing concerning technology transfer.

The study reflected a high level of optimism relating to technology transfer, but how to implement the process was a concern. The cost of establishing a Technology Transfer Office (TTO) may be too high for most TCUs; however, collaborating with area mainstream institutions or other TCUs in a region may be possible. The mission, vision, and goals of TCUs also may not support technology transfer, as basic academic skill building, focus upon culture, language, community, and other local academic needs may consume too much valuable time and resources.

Another possible idea is to create a consortium of TCUs, other mainstream institutions, and even industry, for the development of a TCU Technology Transfer Office (TCU-TTO). The high cost of operating a single TTO could be spread over several collaborators, with each taking a role in the technology transfer process. According to Burnside and Witkin (2008) the increase in global and connected markets in the research and development area makes collaborating in technology transfer more

favorable than ever before. For instance, one organization may have a strong interest in patent law; another may lean towards industry collaborations. The TCU community collaborates on several initiatives, mainly through the AIHEC organization (AHIEC, 2012), and the central TTO could be housed within AIHEC and have several partners spread throughout the United States.

Study Reflections

The lack of technology transfer activity at TCUs sparked an interest to begin this study. The history of TCUs and the focus upon providing higher educational opportunities locally for tribal communities provided further curiosity around the topic. The serious gap in literature pertaining to technology transfer and TCUs drove the study. The amount of literature about TCUs and technology transfer did not indicate much was happening in this area. The purpose of the study was to identify the factors that were affecting technology transfer at select TCUs, add to the literature on technology transfer and TCUs, and to provide potential avenues about technology transfer for TCUs to explore.

Limitations of the study included the wide geographic location of participating TCUs, the travel and coordination required to complete the IRBs and subsequent on-site interviews. The level of technology transfer understanding was better than expected and provided an added level of unexpected optimism to the study. In addition, the participation from presidents, vice presidents, academic deans, and faculty researchers provided a broad representation about the topic, not the limited perspective believed prior to beginning the data collection.

The present study demonstrated the importance to having a wide geographic representation of study participants, each having their own thoughts and perspectives about technology transfer and the potential impacts to their institution and community. The study revealed new information about the level of interest and optimism at these institutions, validated prior suspicions about the amount and level of technology transfer at the selected TCUs, and confirmed the focus upon local academic needs.

The participates in the study validate the classical management theory (Fayol, 1949) that states management must be able to command, organize, control, coordinate, and plan functions within an organization. The process of technology transfer requires all these functions, in addition to the components in the rational theory (Scott & Davis, 2007) that include having the right personnel, tasks defined, and the proper allocation of resources.

Recommendations for Future Research

The present qualitative exploratory case study involved face-to-face, on-site interviews with 20 TCU Presidents, Vice Presidents, Academic Deans, and Faculty Researchers spread across a large geographic region, with additional exploration of institutional archival data and field notes. It would be possible to duplicate the study to other TCUs as the study was based upon sound qualitative case study design with reliability and validity built into the design. Conducting interviews, with a review of archival data at these other TCUs may shed additional light on the level and interest of technology transfer across the entire TCU community.

A Delphi study of TCU Presidents, Vice Presidents, Academic Deans, and Faculty Researchers may be helpful to narrow down the particular areas that may be

hindering or supporting technology transfer that may result from scientific research. Over time, some quantitative data may become available that could also provide further insight into the area of technology transfer and potential impacts upon TCUs.

Chapter 5 Summary

In chapter 1, an overview of the TCU evolution was presented, along with an overview on technology transfer. Chapter 1 also provided the statement of the problem, purpose of the study, significance of the problem, research design appropriateness, assumptions, conceptual framework, limitations, and delimitations of the study. In Chapter 2, a review of the literature and gaps found were highlighted that pertained to the research problem. Chapter 3 detailed the methodology, population, sample, data collection process, validity, reliability, and data analysis to be used in the study. In Chapter 4, the findings were presented, along with a detailed analysis of the how the study results supported these findings. Chapter 5 included explanations around each of the five themes and related six sub-themes, along with recommendations to TCU leadership and future research.

The five themes resulting from the analysis of the data are barriers, optimism, technology transfer strategy, lack of knowledge about technology transfer, and institutional research capabilities. Under barriers, several subthemes emerged, time constraints, lack of administrative support, institutional research capabilities, individual research capabilities, remoteness of institution, and institutional core mission of academics. The themes align with the main research question and the three secondary research questions in the study. Tribal college and university leaders should keep an

open mind and review how technology transfer can play a role in institutional development, both in research activity and academic benefits.

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Appendix A

Sample of Informed Consent

INFORMED CONSENT: PARTICIPANTS 18 YEARS OF AGE AND OLDER

Dear Study Participant,

My name is Steve Dupuis and I am a student at the University of Phoenix working on a Doctorate of Management in Information Systems and Technology degree. I am doing a research study entitled Technology Transfer Process at Tribal Colleges and Universities (TCUs): A Multiple Site Case Study. The purpose of the research study is to answer the question, are TCUs conducting technology transfer, if so how? If not, why not? In addition, does the undergraduate nature of research conducted at TCUs have any effect on their ability to conduct technology transfer? Technology transfer is commonly referred to as the process of moving knowledge and research project results into private industry through licensing, spin-offs, partnerships, or other means. The purpose of this study is to explore technology transfer at TCUs.

You are invited to participate because you have been identified by the president of your institution as a leader in this area. Your participation will involve an interview where you will be answering open ended questions. The interview is anticipated to last one hour. Our discussion will be audio recorded for accuracy and your participation is strictly voluntary and can be withdrawn at any time. In addition, your responses can also not be used in final study results. The number of participants is expected to be around 20 from four different institutions. You can decide to be a part of this study or not. Once you start, you can withdraw from the study at any time without any penalty or loss of benefits. The results of the research study may be published but your identity will remain confidential and your name will not be made known to any outside party.

In this research, there are no foreseeable risks to you in participating in this study.
Although there may be no direct benefit to you, a possible benefit from your being part of this study is to inform TCUs about the benefits and risks associated with technology transfer.
If you have any questions about the research study, please call me at (XXX) XXX-XXXX or email me at _____. For questions about your rights as a study participant, or any concerns or complaints, please contact the University of Phoenix Institutional Review Board via email at IRB@phoenix.edu.
As a participant in this study, you should understand the following:

You may decide not to be part of this study or you may want to withdraw from the study at any time. If you want to withdraw, you can do so without any problems.
Your identity will be kept confidential.

Steve Dupuis, the researcher, has fully explained the nature of the research study and has answered all of your questions and concerns.

If interviews are done, they may be recorded. If they are recorded, you must give permission for the researcher, Steve Dupuis, to record the interviews. You understand that the information from the recorded interviews may be transcribed. The transcribed data will be coded to assure that your name is protected.
Data will be kept in a secure and locked area. The data will be kept for three years, and then destroyed. The results of this study may be published.

"By signing this form, you agree that you understand the nature of the study, the possible risks to you as a participant, and how your identity will be kept confidential. When you sign this form, this means that you are 18 years old or older and that you give your permission to volunteer as a participant in the study that is described here."

(☐) I accept the above terms. (☐) I do not accept the above terms. (CHECK ONE)

Signature of the interviewee _____ Date _____

Signature of the researcher _____ Date _____

Appendix B

Onsite Interview Questionnaire

Study Title:

Technology Transfer Process At Tribal Colleges And Universities: A Qualitative Multiple Site Exploratory Case Study.

Investigator:

Steve Dupuis

Subjects:

TCU Presidents, Administrators, faculty, and staff

Questionnaire:

The purpose of this qualitative exploratory multiple site case study is to identify the factors that are affecting technology transfer at the selected TCUs. TCUs need to evaluate and understand the potential impacts undergraduate STEM research may have upon technology transfer. TCUs also need to understand the impacts technology transfer may have upon the institution. The process may include such things as: Identifying new ideas and technologies; utilizing copyrights and patents to protect intellectual property; and developing strategies to market and license new technologies to private sector companies.

You have been selected, based upon your potential involvement regarding technology transfer related matters at your institution, either by your position or research experience. The following questions will be part of our interview. Your responses will be used to develop a better understanding of technology transfer activities. This interview will be audio recorded for accurate transcription purposes only. All

information provided will remain confidential. The separated Informed Consent agreement will detail the rights and responsibilities for all involved parties in this study.

Name:

_____

Job title:

_____

Major Duties:

_____

Personal knowledge and experience with technology transfer

How much do you know about the patents, copyrights, and the protection of intellectual property?

Have you established connections with people from other institutions or other businesses that is related to any research project? If so, please explain.

Do you or have you lead research projects with students and/or on your own? If so, please explain

How would you describe your research capabilities?

What are your thoughts about seeking profit from a discovery that could be beneficial to society?

Do you have an entrepreneurial spirit?

Organizational culture

Does your institution have a policy that addresses intellectual property?

How many full-time PhD faculty members in STEM are at your institution?

How much Federal, state, local, or foundation dollars are spent upon undergraduate research projects?

Are there any national, regional, or local organizations from the private sector that has sought or is currently collaborating with your institution on a research project?

Is your institution interested or involved with local economic development?

What would be the primary research interests of your institution's faculty and students?