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The Intersection of Discipline and Roles: Dr. Pauline Mack's Story as an Instrumental Case Study with Implications for Leadership in Science, Technology, Engineering, and Mathematics

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AS

AN INSTRUMENTAL CASE STUDY

WITH IMPLICATIONS FOR

LEADERSHIP

IN

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Title: The Intersection of Discipline and Roles: Dr. Pauline Mack's Story as an Instrumental Case Study with Implications for Leadership in Science, Technology, Engineering, and Mathematics

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Widespread concerns currently exist regarding our nation's ability to attract, educate, and retain talented, diverse individuals in STEM fields. These concerns are exacerbated by globalized competition and critical economic conditions. With these issues in mind, this instrumental case study was designed to examine the life story of Dr. Pauline Beery Mack in order to inform secondary and tertiary educational leadership in science, technology, engineering, and mathematics (STEM). Dr. Mack's life story was written from the interpretive view and analyzed through a number of theoretical frameworks appropriate to understanding the complexity of an individual in time and place: the psychobiosocial model, constructivism, creativity, perspective of the field, and the capstone framework of leadership. Data for the construction of Dr. Mack's life story were obtained from Pennsylvania State University Archives, The Women's Collection at Texas Woman's University (TWU), original publications, news media archives, and other sources. Interviews conducted for TWU's archives and interviews conducted by the author provided personal insight into Dr. Mack's life and work.

Dr. Mack (1891-1974) lived, learned, created, and taught in a STEM arena that was predominately male. She pursued research with zeal, and was highly adept in attracting jobs, funding, students, and the right people to get the jobs done. Her

longitudinal nutrition research, based on a methodology she invented, was innovative in its scope and scale. She served as an advocate for consumers, the undernourished, women, and minorities. Along the way, she changed perceptions of what women could accomplish. Bone density, school lunches, Victory Gardens, flammability, textile industry scandal, and space travel- Dr. Mack with her insatiable need to know was involved in it all. Her multiplicity of roles and contexts yielded a rich and complex life from which to draw implications for educational leadership in secondary and tertiary STEM fields.

Implications for educational leadership in secondary and tertiary STEM fields that emerged from this study, relating to both affective and academic spheres, range from STEM valuing, discipline-related expertise, divergence value modeling, and expectations. Among the other implications addressed are levels of thinking, scaffolding for attribute development, and working on the work.

ACKNOWLEDGEMENTS

As Dr. Mack's life story reveals, no significant endeavor is accomplished by the individual in isolation. The lifetime contributions of many talented individuals provided the foundational knowledge and frameworks supporting this study. With appreciation to all, I would like to thank Dr. Howard Gardner and Dr. Seana Moran for their contributions to a novice attempting to grow her knowledge.

Indiana University of Pennsylvania has managed to put the right people in the right place in the educational leadership program. Each of the University's talented educators has contributed a unique piece in the effort to assemble the leadership puzzle. In acknowledging their contributions, it is necessary to start with Dr. Cathy Kaufman, my dissertation chair, who during our first class in the program started us with the end in sight by leading us over to the football field to see the graduation in progress. Her creative and knowledgeable teaching style and leadership have served us admirably. I appreciate the support and enthusiasm of Dr. George Bieger and Dr. Monte Tidwell, my committee members. I would also be remiss if I didn't acknowledge Dr. Wenfan Yan, whose *do it, do it right, do it right now* caveat seems to be forever emblazoned on my mind! Thank you to the above professors and Dr. Robert Millward, Dr. Anne Creany, Dr. Joseph Marcoline, Dr. David Piper, and Dr. Sue Rieg for a quality program.

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Jean Sherrill, Dr. Mack's secretary at Penn State, will be forever remembered. Texas hospitality is amazing and I am thankful for the time I spent at TWU with so many wonderful people who care about the history of TWU and the work that occurred there.

My family has been very supportive while I have been immersed in documents and mentally focused in another era of history. I am fortunate that my husband, Dennis, is as patient, tolerant, and supportive of me as Warren Mack was of Pauline. His travels with me to IUP, Gettysburg, and Texas enriched my pursuit of Dr. Mack's life story.

Dedicated to Dr. Pauline Beery Mack

Pennsylvania and Texas Pioneer

and all who persevere with

courage and creativity

for the benefit of

students

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CHAPTER I

THE PROBLEM

Background of the Problem: A Changing Context for the 21st Century

Our 21st century presents critical challenges for the American workforce and leaders in diverse fields who frequently operate in complex, perpetually shifting contexts. The challenges are especially acute for educators responsible for preparing all students with the attributes, knowledge, and skills to succeed in rapidly changing times in order to maintain and enhance our nation's economy, security, and individual and collective quality of life. The 20th century served as a prelude to our unsettling times. The closing decades were underscored by technological advances that, while appearing antiquated by today's standards, produced outcomes that have essentially affected every global inhabitant, though not eliminating the continuing struggles societies face pertaining to gender, race, and minority issues. We have fast-forwarded from Jobs' and Wozniak's tinkering that lead to the 1977 release of the Apple II home computer, past the 1990 release of the user-friendly 3.0 version of Windows, through subsequent reductions in physical and geopolitical barriers once preventing a vision of a unified world, to a flattened world created in part by millions of individuals with digital shovels (Friedman, 2006). Educational, economic, cultural, and political landscapes have been shaped even more by the combined synergy of open access to information and the ability of individuals to author content from their desktops in digital form and to disseminate it through continually improving telecommunications. Friedman, who credits the ascendancy of the Windows-enabled PC and the fall of the Berlin Wall with initiating an entire global flattening process,

highlights the significance of one of Bill Gates' early maxims for Microsoft- the company would give every individual IAYF, information at your fingertips. IAYF has been realized due to the contributions, foresight, and creativity of many. Microsoft's role in the creation of our current milieu was visible at the 1995 celebration of the release of Windows 95. At the conclusion of a festive program held in a vast tent at Microsoft's headquarters, the rear tent wall was released, revealing as it cascaded to the ground Microsoft's programmers wearing Windows colors while artfully arranged on bleachers to personify the Windows logo. In 1995 this public recognition served as a powerful image of teamwork and corporate identity. In retrospect, it may have been even more compelling for the visualization of falling barriers portrayed by the released tent wall and the bleachers embodying Microsoft's contributions to accelerating the flattening of the world playing field for information creation, exchange, and competition.

The forces of globalization are not tapering. A guiding notion from the 2007 Leadership Forum provides us with a powerful image of a dynamic, accelerating process: "The leveling winds of globalization gust as never before, hastening the pace of change in every society in the world," (Institute for Educational Leadership (IEL), 2007, p.1). Changes in the global environment, spurred by technological leaps, have and will continue to affect individuals, organizations, cultures, and nations. IEL notes that with economic and cultural events superseding traditional borders, prosperity of even the remotest and most stable communities will require adaptation. The 21st century brought with it a switch from a buyer's to a seller's market, whereby companies that no longer have their choice of the best talent must compete to locate,

attract, and keep talented individuals (Levey & Levey, 2000). Levey and Levey note a study by the American Management Association in which more than 50% of the respondents had suffered recent losses of enough talented individuals that their competitive ability was greatly compromised. Samuel A. DiPiazza Jr., Global Chief Executive Officer for PricewaterhouseCoopers, addressed this issue at the World Economic Forum Annual Meeting (2006, p.16): "In my 30 years experience I have never seen such an incredible shortage of talented people- whether it is in Germany, Brazil, China, India or Kansas." High skill/high wage occupations with the fastest growth are employing *gold collar* workers who are resourceful at solving problems and have appropriate training with education beyond high school to work in frequently dynamic work environments (Pennsylvania Partnerships for Children, 2006). In order to be economically self-sufficient, contributing members of society, individuals need at least a solid academic background with significant mathematics aptitude, English skills, and advanced skills in communication, thinking, and problem-solving (Pennsylvania Partnerships for Children; United States Department of Education [USDOE], n.d.a; USDOE, n.d.b; Van de Walle, 2004). While individuals and organizations grapple with the knowledge, skills, and attributes perceived as necessary to successful navigation of the 21st century, trends and events in a core group of interrelated fields are tripping alarms nationwide. Concurrently, in spite of technological advances and rapid change, most societies continue to struggle with issues pertaining to gender, race, and minority status.

There is intense and growing concern, detailed in commission reports and political offerings over the past several decades, regarding the perception that

education is failing to produce sufficient numbers of highly-qualified individuals in science, technology, engineering, and mathematics (STEM) fields that are vital to our nation's defense, economy, and the solution of global problems (Baldi et al., 2007; Duderstadt, 2008; ISTE, P21, & SETDA, 2007; Kadlec, Friedman, & Ott, 2007; Loveless, 2007; National Center on Education and the Economy, 2007; National Research Council, 2008; Olsen et al., 2007; Willoughby, 1983/1984). This concern is echoed in a survey conducted for the Association of American Colleges and Universities, in which more than 60% of the employer respondents said that recent graduates did not have the skills to succeed in a global economy (Fischer, 2007). According to the U.S. Chamber of Congress (2007, p. 5):

> It has been nearly a quarter century since the seminal report A Nation at Risk was issued in 1983. Since that time, a knowledge-based economy has emerged, the Internet has reshaped commerce and communication, exemplars of creative commerce like Microsoft, eBay, and Southwest Airlines have revolutionized the way we live, and the global economy has undergone wrenching change. Throughout that period, education spending has steadily increased and rafts of well-intentioned school reforms have come and gone. But student achievement has remained stagnant, and our K-12 schools have stayed remarkably unchanged- preserving, as if in amber, the routines, culture, and operations of an obsolete 1930s manufacturing plant.

Other reports, studies, and articles address issues pertaining to attraction and retention of individuals in the STEM pipeline and continued issues of bias and organizational structures that interfere with retention and promotion of qualified individuals.

Chapter II presents a detailed review of the literature related to these issues. Our present and future worlds present tremendous challenges for leaders, organizations, and learners, evidencing why the World Economic Forum's Annual Meeting (2006) focused on the solutions-driven theme, "The Creative Imperative." The amazing changes that emerged over the course of the 20th century are miniscule in comparison with the accelerating rate of change driving our present and our future and the ramifications of effectively learning, working, living, and leading in this context.

Statement of the Problem

Given the complexity and interconnectedness of the flattened world and global environmental, economic, and health issues, we cannot afford to ignore or perpetuate organizational, social, and cultural barriers to effective engagement of all individuals as lifelong learners and as productive, informed citizens. The problem specifically addressed by this study is our need to understand the processes, challenges, and barriers in education, leadership, and participation in STEM fields to inform secondary and tertiary educational leadership as an element of the efforts to successfully address the urgent issues that are continually emerging from our accelerating, flat world. Greater understanding of these processes and issues can grow our capacity to address the challenges of the 21st century and the responsibilities and issues noted by IEL (2007, p.1): (a) the responsibility of educators to prepare citizens to function in a democratic system pummeled by transformative forces; (b) the difficulty leaders face in rapidly changing environments, as developments frequently outpace the range of policy vision; (c) the work citizens must undertake to understand and embrace diversity for societies to benefit from the strength and adaptability

diversity can offer; and (d) the potential for new technology to play an essential role in solving a variety of problems, if it is utilized appropriately by leaders who are cognizant of its limitations.

Purpose of the Study

The purpose of this instrumental case study is to examine the particular case of a female educator and scientist, who lived, learned, worked, and created in a male-dominated field and culture, in order to gain insight for secondary and tertiary leadership in STEM fields. The complexity, richness, nuances, uniqueness, and commonalities of an individual and her life, in this case Dr. Pauline Mack, provide fertile ground for individuals seeking to address the complexities of effective leadership in the context of the intensely growing demands of the 21st century.

Theoretical Framework

Lives lived are multifaceted and nuanced. Theoretically, this study is informed by Halpern's (2006) psychobiosocial model. Examined in detail in Chapter II, Halpern's dynamic model addresses the complexity of academic learning and achievement in conjunction with gender issues. As such, it is particularly relevant to this instrumental case study of Dr. Pauline Mack, who created her life while educating and researching in a male-dominated field and cultural era.

Chapter II also includes a review of relevant literature pertaining to constructivism, creativity, leadership, and metrics of success. Constructivism provides insight into teaching and learning environments, actions, and decisions, as well as foundational support for enhanced development of leadership implications. Creativity is fundamental to discovery, invention, and innovation in varied contexts.

Historical perspectives on leadership promote a deeper understanding of the contexts in which Dr. Mack learned and worked and leadership she may have exhibited. The leadership literature also provides a foundation for the leadership implications deriving from this study. Pertinent literature on metrics of success contribute to an understanding of the issues surrounding the nature of scholarship and support for interpreting evidence of Dr. Mack's scholarship and contributions to the field. Though each of these areas provides an individual spotlight contributing to an understanding and interpretation of Dr. Mack's life and future implications for STEM leadership, the interconnections are evident and the combined perspectives yield a floodlight to guide this study.

Research Questions

This study addresses the following research questions:

1. What factors contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science?
2. What patterns or connections to the theoretical frameworks of constructivism, creativity, and leadership are evidenced by the traits and behaviors displayed by Dr. Mack?
3. What transforming moments or epiphanies are evidenced?
4. What, if any, educational, career, and life challenges did Dr. Mack experience that pertained to stereotyping, gender, bias, or other issues revealed by this study?
    a. How did Dr. Mack address identified challenges and in what ways did they influence her decisions?

b. Were there mediating factors that supported successful handling of challenges?

5. How did the field perceive and recognize Dr. Mack? Is there evidence in retrospect to corroborate or refute the perceptions of her time?
6. What implications do the findings from this research have for secondary and tertiary STEM educational leadership?

Definition of Terms

Academic achievement – what an individual has already learned in an area (Halpern, 2006) as contrasted with an individual's ability to benefit from instruction in a particular area.

Agency – a fundamental psychological drive to control one's destiny (Ruderman, 2004).

Biological clock – timing mechanisms developed by living organisms (Rensing, Meyer-Grahle, & Ruoff, 2001); the reference to women's biological clocks refers to declining fertility over time, found to be true for men as well (Reuters, 2002).

Challenges – conditions of the environment that regulate growth, providing opportunities to improve through the exercise of attention, understanding, and creativity (Senge et al., 1999).

Cognitive abilities – in general, the ability to benefit from instruction in a particular area, as contrasted with and difficult to isolate from, academic achievement (Halpern, 2006).

Constructivism – a theory about knowledge and learning incorporating both what knowing is and how one comes to know (Fosnot, 2005a & 2005b); learning is viewed

as an interpretive, recursive nonlinear building process by actively engaged learners interacting with both the physical and social environment (Fosnot & Perry, 2005).

Creativity – the novel and appropriate outcome of the interaction of individual, field, and domain that affects the way other individuals in the field utilize domain resources (Moran, 2008).

Descriptive stereotypes – the group of traits and attributes perceived to uniquely describe men and women (Welle & Heilman, 2005).

Domain – the task, symbolic, or knowledge-oriented aspects of an interaction; organized body of knowledge and symbol systems (Moran, 2008).

Field – the social or power-oriented aspects of an interaction; a socially connected group often organized into institutions (Moran, 2008).

Glass ceiling – popularized in the 1980s, the term refers to a barrier that is simultaneously so subtle as to be transparent and so strong that it prevents women and minorities from advancing up a management hierarchy (Morrison & Von Glinow, 1990/1995).

Mediation – a means (i.e. dialogic, visual, or actional) by which mental processing is invoked, typically between an individual with greater expertise and a novice learner, important to explicating inter- and intra-mental ideas (McGregor & Gunter, 2006).

Prescriptive stereotypes – the set of attributes and traits that depict how men and women "should" be (Welle & Heilman, 2005).

Psychobiosocial – mutual influences of psychological, social, and biological variables on each other (Halpern, 2006).

Role – encompasses how an individual acts in predictable ways depending on his or her knowledge or beliefs and his or her social situation in terms of identity and power relative to others (Biddle, 1986; Moran, 2008).

Stereotype threat – refers to being at risk of confirming, as self-characteristic, a negative stereotype regarding one's group, suggesting that an individual's academic performance can be negatively affected by an awareness that his or her behavior could be perceived through a stereotypic lens (Ackerman & Lohman, 2006; Steele and Aronson, 1995).

Trait – refers to an individual's general characteristics, including capacities, motives, or patterns of behavior (Kirkpatrick & Locke, 1991/1995).

Method of the Study

Dr. Pauline Mack, the subject of this study, lived, learned, created, and taught in a STEM arena that was predominately male. Her multiplicity of roles and contexts, discussed in greater detail in Chapter III, undergirds the rationale for her selection as the subject for this study. Qualitative and instrumental in nature, this study is designed to yield a portrait of Dr. Mack's life that reflects richness and complexity, what Slavin (2007) refers to as a thick description, providing insight for leadership in STEM contexts. Given the biographical nature of the study, primary and secondary historical documents and artifacts provided much of the necessary information needed to present Dr. Mack as a complex individual (Stake, 1995). In addition, the potential existed for locating individuals who had known Dr. Mack. Interviews of individuals who were able to supply first-hand knowledge added to the multiple perspectives provided by archival and other documents and contributed to the triangulation of data.

Data collection was interspersed with analysis and synthesis, with similarities and patterns suggesting appropriate coding categories. This was a recursive process, with the data crafting the puzzle pieces and picture that was eventually revealed (Slavin). Chapter III provides a detailed description of the methodology employed.

Significance of the Study

The exploration of Dr. Mack's life provides us with a window into the complexities and nuances of engagement in the dual professions of education and science while facing organizational and cultural impediments. Although the understandings gleaned from this study have significance for leaders at all levels, the particular focus of this study is intended to inform secondary and tertiary educational leadership. Leadership challenges abound at all levels in numerous contexts. For instance, while some leaders recognize the importance of STEM fields and the need for schools to strengthen student skills in science, mathematics, and technology, students and parents don't necessarily share that view. Public Agenda, as part of a three-year public engagement project on science, mathematics, and technology education, surveyed Kansas and Missouri parents and students (Kadlec, Friedman, & Ott, 2007). The results revealed that while parents and students recognize the importance of these subjects and are aware of our lackluster performance, most consider the subjects not relevant to their personal interests and goals. Parents and students also did not appear to realize that many future jobs will demand significant understanding of these subjects. In responding to the findings of the report, the National Science Teachers Association (2007) speaks to the leadership challenge:

> America's global competitiveness and its ability to remain at the forefront of innovation depend on how well we educate our nation's youth in science and mathematics. Policymakers and business leaders understand this, but the Public Agenda report tells us that many parents don't realize that quality science education is important to their child's future. We need to engage parents by embarking on an aggressive outreach campaign to educate them about the critical importance of science literacy to America's future and inspire them to take a more active role in helping to reform science education. (p. 29)

Organizational and social impediments of Dr. Mack's era have not been eradicated and continue to present vexing challenges. Rolison (2007, p. 3) highlights the need for greater inclusion and equity in the face of intelligent, creative young women who are opting out of STEM faculty ranks and staff scientist positions at federal and national labs and our "shameful inability to incorporate these talented women into their rightful roles as leaders and innovators of U.S. science and technology." Gender issues are still apparent, highlighted by allegations such as those of eight Pennsylvania State University's College of Medicine professors. The professors filed a lawsuit in April 2007 in U.S. District Court in Scranton, Pennsylvania following years of arguing about gender bias pervading the medical school, with male counterparts receiving greater pay and benefits (Gravois, 2007). Perhaps a picture is most telling of the significance of learning about the experiences of organizational and social impediments in all their complexities to grow our capacity to effectively ameliorate them: Despite a pledge by the Massachusetts

Institute of Technology nearly a decade ago to address gender discrimination experienced by female faculty members, women are still attaining tenure at a lower rate than men over the past ten years (Williams June, 2007). In the collection of photos published by the university's in-house newspaper of faculty members granted tenure to date in 2007, only one was female. Of the 25 faculty members granted tenure, 24 were male.

Possibly the greatest significance of this study is what the individual reader can draw from the complexity of a life story as it pertains to the reader's role, interests, and challenges in contexts pertaining to 21st century STEM secondary and tertiary educational leadership. While referring to our debt to tradition, absence of pure originality, and the reality that all minds quote, Emerson's words also have a particular relevance to this study: "Old and new make the warp and woof of every moment. There is no thread that is not a twist of these two strands" (Emerson, 1876). Twisting these strands can lead us to deeper understandings needed to address current and future challenges.

Limitations of the Study

Qualitative case studies present a number of inherent challenges and limitations (Creswell, 1998; Denzin & Lincoln, 1994; Slavin, 2007; Stake, 1995). The researcher needs to determine which bounded system is worthy of study from an array of possibilities. The selection of one individual for study, while providing opportunity to explore the depth, richness, and nuances of life processes, events, and challenges, negates a deep exploration of a singular issue that would support generalizability. Conclusive proof or disproof of hypotheses are not possible in this

type of study due to the context-bound nature of the qualitative methods employed (Slavin). In addition, there is the challenge of ensuring that the researcher has enough information to create the necessary thick description. The researcher also needs to be aware of the limitations of her own perceptions and must guard against personal bias and stereotypical portrayal of the subject. The experiences, intentions, and frame of mind of the researcher cannot be totally divorced from the qualitative case study approach and potential effects on shaping the narrative and deriving interpretation. As such, the researcher is challenged to "give the reader a good look" at herself (Stake, p. 95).

Summary

Our world has changed and continues to change at increasingly faster rates, with much of this change attributable to technological advances. The demands are intense to attract, educate, and retain talented individuals in STEM fields to grow our capacity to solve increasingly complex global problems as well as economic and quality of life challenges. At the same time, barriers and challenges of earlier eras continue to interfere with assuring, as Collins (2001) puts it, that the right people are on the right seat on the right bus. The depth of a particular life story, with all its complexity and nuances, provides insight to inform leadership at secondary and tertiary levels in STEM disciplines to eliminate barriers and address challenges. Chapter II provides the theoretical frameworks for an in-depth examination of Dr. Pauline Beery Mack's life story and the lenses for interpreting the findings of this study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The purpose of this study is to examine the particular case of an individual who was both scientist and educator in order to gain insight for secondary and tertiary educational leadership in science, technology, engineering, and mathematics (STEM) disciplines. The complexity of the individual and her life examined in this study provides fertile ground for individuals striving to address the complexities of effective secondary and tertiary educational leadership within the burgeoning demands of the 21st century.

This instrumental case study examines the life of a female scientist and educator, Dr. Pauline Mack (1891-1974), who was somewhat contemporaneous with the creative individuals of the modern era explored by Gardner (1993). Gardner, as a social scientist, researched several lives in a search for similarities and informative differences. In contrast, this study focuses on a lesser-known individual in order to understand her particular challenges, contributions, experiences, choices, and attributes as she engaged in the fields of science and education. During our current era of intense scrutiny and concern in science and education (as well as technology, engineering, and mathematics), the particulars of this life unfolded can provide insight for others who are striving to provide leadership in secondary and tertiary educational settings.

Just as individuals and lives are complex and layered, so are the potential contributing theoretical frameworks for this study. Multiple theories and frameworks that address issues of cognition, gender, and environmental factors offer relevant lenses. However, because Dr. Mack's life took shape while learning, living, creating, and

teaching in a male-dominated field and culture, the psychobiosocial model that addresses the complexity of academic learning and achievement while addressing gender issues appears to be principally germane. In addition, Chapter II of this study includes a review of relevant literature in the areas of constructivism, creativity, leadership, and metrics of success. Constructivism as a theory about learning and its implications for an educator's practice facilitates a deeper understanding of Dr. Mack's teaching and learning environments, actions, and decisions. In view of the instrumental nature of this case, the constructivist framework offers foundational support for enhanced development of leadership implications. Creativity is fundamental to discovery or invention in any context and is particularly relevant in examination of a dual-profession life, as Dr. Mack worked in the intersection of her scientific discipline and her role as educator. Instrumentally, greater understanding of the literature on creativity contributes to our understanding of the nature of teaching, learning, and working in STEM fields and the implications for STEM leadership, which demands creative and effective strategies to meet the growing challenges of our 21st century. An examination of the historical perspectives on leadership facilitates our comprehension of the contexts in which Dr. Mack learned and worked, lenses for interpreting leadership she may have evidenced, and underpinnings for the STEM leadership implications deriving from the instrumental aspects of this study. The final section of this literature review, in exploring how success is perceived and measured, contributes to an understanding of an ongoing dialogue regarding the nature of scholarship, interpretive lenses for evidence of Dr. Mack's scholarship, and indications for consideration in STEM leadership. While the literature review provides an examination of germane theories, frameworks, and research in these

various areas, intertwining connections and relationships are evident. Separate consideration contributes to clarity and manageability, but it is essential to remember that individuals are complex beings living in increasingly complex worlds.

Women's Achievement and Gender

A Psychobiosocial Model

Perhaps nothing is more inflammatory than the explicit framing of innate differences in intellect and/or ability along gender (or racial) lines. Consider the outcry resulting from former Harvard President Lawrence Summers' (2005) remarks that addressed the following hypotheses for the underrepresentation of women in high-end scientific professions: high-powered job expectations, different availability of aptitude at the high end, and different socialization and patterns of search discrimination (ranked in his view of their relative importance). The second of his hypotheses, regarding innate gender differences in scientific aptitude, reverberated across academia into view of the general public. In Summers' words:

> "So my best guess, to provoke you, of what's behind all of this is that the largest phenomenon, by far, is the general clash between people's legitimate family desires and employers' current desire for high power and high intensity, that in the special case of science and engineering, there are issues of intrinsic aptitude, and particularly of the variability of aptitude, and that those considerations are reinforced by what are in fact lesser factors involving socialization and continuing discrimination."

The brouhaha over these remarks ultimately led to Summers' resignation. Emily Riehl (2005), an aspiring mathematics professor and student at the time of Summers' remarks,

offered her belief that her work as a mathematician would be judged on its own merits. She also perceived that attaining employment might be a challenging task in departments akin to Harvard's, which at that time had never had a female tenured professor of mathematics. Riehl highlighted the importance of earning the respect of her peers, who would also be her future colleagues, not by being a statistical anomaly as a female capable of mathematical reasoning, but simply for her abilities. Her expectations are insightful. Though we are in the beginnings of the 21st century, she does not believe that science and mathematics will ever become gender-blind.

In reviewing the literature on women's achievement and gender, it is helpful to incorporate the framework for understanding cognitive sex differences as depicted by Halpern (2006). The psychobiosocial model recognizes that researchers examine separate aspects when comparing female and male cognition and academic achievement and considers these separate contributions necessary to understanding a gestalt, or how the various elements work in conjunction to influence each individual's cognitive abilities (Halpern, 1997; Halpern, Wai, & Saw, 2005; Halpern, 2006). That mutual influence of psychological, social, and biological variables is what Halpern (2006) references when employing the term psychobiosocial. Halpern uses the example of learning, which is both socially mediated and biological in nature. Individuals have a predisposition to learn some concepts more easily than others. This predisposition is derived from prior learning experiences, neurochemical processes, and change in areas of the brain resulting from learning. Psychological variables, including interest and expectancy, affect how readily learning occurs, yet they are also affected by previous learning. Halpern has reframed the debate of nature versus nurture with this circular dynamic model. Many of the issues

surfaced by Summers' (2005) hypotheses relate to the model's elements and dynamic interactions. This literature review of the research on women's achievement and gender presents separate aspects that have been researched that can provide insight into Dr. Mack's life events. However, it is the dynamic nature of the psychobiosocial model that makes it highly suited to developing a deeper understanding of Dr. Mack's life in all its human complexities in the context of the world in which she lived.

Sex Differences and Similarities in Intelligence

In reviewing the research on cognitive sex differences, Halpern (1997) indicates that sex differences in intelligence are dependent upon the aspects of the cognitive task, the range of ability tested, the participant's age and education, and a variety of other modifying and context variables. Females excel in some intellectual areas and males excel in others. She reminds us that data do not indicate that either sex is smarter than the other and also do not suggest that the differences are immutable. Halpern (2006) discusses the emerging view of sex-related cognitive abilities. While there are many cognitive tests and academic indicators that reveal no difference in academic achievement/cognitive ability of males and females, there are metrics showing large and consistent differences favoring females and others favoring males. The differences hold over time and place, indicating they are systematic and not the result of random variance. Halpern suggests it is beneficial to consider the differences in light of the cognitive processes used in thinking instead of the academic areas assessed in schools. She uses the example of data that indicate girls outperform boys on arithmetic computational tasks, while boys outperform girls in mathematic concept/application tasks. The differing

outcomes may be an example of the typical finding that girls retrieve from memory better and therefore have better retrieval of facts.

Feingold (1988) examined gender differences based on norms from four standardizations of the *Differential Aptitude Tests* (DAT) performed between 1947 and 1980 and from four standardizations of the *Preliminary Scholastic Aptitude Test/Scholastic Aptitude Test* conducted between 1960 and 1983. He found that girls' performance was superior to boys' on measures of grammar, spelling, and perceptual speed, while boys outperformed girls on measures of spatial visualization, high school mathematics, and mechanical aptitude. He did not find any average gender differences on measures of verbal reasoning, arithmetic, and figural reasoning. Feingold found that gender differences declined sharply over the years surveyed, with increases in the differences over the high school years diminishing. The exception to his findings of disappearing gender differences was in the upper levels of performance on high school mathematics, which remained constant over 27 years. Halpern (1989) took exception to Feingold's argument and findings that cognitive gender differences are disappearing, pointing out that hundreds of studies have revealed consistent gender differences on subtests in three cognitive areas: female superiority in verbal abilities and male superiority in visual-spatial and mathematical abilities.

Masters and Sanders (1993) refer to the meta-analysis used by several researchers and the conclusions drawn that the magnitude of gender difference in spatial ability is declining over time. They utilized meta-analytic techniques to compare the effect size of gender difference in 14 studies published from 1975 to 1992 in which the Mental Rotations test was administered to adolescents and young adults. They found that males

significantly outperformed females in all the studies, with the magnitude of the gender difference on the Mental Rotations test remaining stable over time. Their findings contradict the general conclusion that gender difference in spatial ability is declining. Feingold (1993) compared the past and present trends in gender differences by age from the standardizations of the Wechsler Intelligence Scales (1949-1981) and the California Achievement Tests (CAT; 1956-1985). Gender differences for children were small or nonexistent; decreases in gender differences, in line with prior research, were found for adolescents; gender differences for adults were frequently found on subtests of the Wechsler scales.

In a global look at this debate, Colom, Quiroga, and Juan-Espinosa (1999) used the norms from two standardizations of the DAT and the Primary Mental Abilities (PMA) conducted between 1979 and 1995 in Spain. Males outperformed females in the DAT subscales of Verbal Reasoning, Numerical Ability, Spatial Relations, and Mechanical Reasoning, in addition to the PMA subscales of Numerical Ability and Mental Rotation. Females scored higher in Inductive Reasoning in the 1979 and 1995 standardizations of the PMA. The researchers concluded that their findings indicate that there are still some differences that favor females and some that favor males. Cahan and Yael's (1995) study of cognitive gender differences among Israeli children found a gender gap in mathematics that the author notes may be related to differential expectations and treatment of both genders, which is relevant in the area of mathematics.

Social Learning Theories

Social learning theories offer the perspective that the sex-typed practices of the socializing community are of the greatest significance in creating and understanding

nonreproductive differences between males and females (Halpern, 1997). Halpern surfaces the difficulties in testing social learning theories, as it is nearly impossible to attain the experimental control required to infer causality. Real-world contexts and variables are rather messy to examine. Halpern provides the example of the finding that participating in spatial activities is important to the development of spatial abilities and females participate in fewer of these activities than males. Why? Is it because females have been socialized to engage in other types of activities? Is it due to their having less spatial ability and, as a result, less interest? Is it a combination of both? Is an initially small sex difference enlarged through social practices with differing experiences? The question then becomes whether or not education and training can mediate the differential. A number of experiments have shown that spatial ability can be improved through training, though males still outperform females following training. Halpern reminds us that education is one of the most significant variables in predicting achievement levels in a cognitive domain. Skills can be learned through appropriate instruction, with improvement on cognitive tests possible for practically all learners.

In an examination of the social and psychological processes involved in gender-roles and women's achievement, Eccles (1986) observes that conversations regarding sex differences in achievement need to take into account both the issues of societal influence on how achievement is defined in the first place and our evaluation of the differential worth of differing forms of achievement. She comments that both of these are value-laden enterprises, suggesting that social scientists frequently utilize a male standard of ideal achievement as they attempt to comprehend why women do not achieve like men without taking into account that women may be choosing an alternative activity rather

than avoiding a particular one. Eccles and her colleagues propose a model that analyzes women's "underachievement" from the perspective of choice instead of from a deficit view. This achievement model connects academic choices to students' expectations for their performance on different achievement tasks and to the importance they place on those tasks. The prediction in applying this model to educational and occupational choices would be that the value individuals place on a range of choices they perceive as appropriate and their estimations of the probability of success with that range of options have the most direct bearing on their choices. Several aspects of this model facilitate understanding sex differences in educational and occupational choices: (a) the model assumes that the effects of experience are mediated by how the individual interprets the events rather than by the events themselves; (b) the model focuses on choice as an outcome of interest, as "many of the most significant sex differences occur on achievement-related behaviors that involve the element of choice, even if the outcome of that choice is heavily influenced by socialization pressures" (p. 15); (c) the model takes into account that individuals do not consider a full range of viable options, either because of lack of awareness, inaccurate information, or the lack of congruence with the individual's gender-role schema; and (d) the model assumes that achievement decisions take place in the context of a complex social reality, presenting each individual with wide-ranging options, each with long-range and immediate consequences.

Findings of longitudinal studies to test the usefulness of the model indicate that males and females have varying attributional patterns that might exert influence on academic choices. Eccles (1986) asserts that comparable attributional variations may also mediate sex differences in occupational decisions. In looking at the potential usefulness

of her model, Eccles suggests that it offers a method for increasing perceptions of career options for both women and men through programs addressing individuals' beliefs in educating them to (a) associate different attributions and expectations with different occupations; (b) gauge the value they place on occupations; (c) re-assess the stereotypes they hold of different occupations and life-roles; and (d) re-evaluate the congruence between different career options and one's adult-role plans.

Political and Emotional Ramifications

Glass ceiling. Social inequalities like glass ceilings and mommy tracks, impediments to women in Western countries, contribute to the comprehensible reluctance of psychologists to engage in research pertaining to gender differences in intelligence because of the danger of the resulting data being misapplied in the service of a misogynist agenda (Halpern, 1997). The glass ceiling concept as popularized in the 1980s portrays both the strength of a barrier that blocks the progress of women and minorities from upward movement into higher-level positions and its subtlety by its transparent nature (Morrison & Von Glinow, 1990/1995). Dr. Rita Colwell, National Science Foundation (NSF) Director, recalls that during her high school years girls were not permitted to take physics (2001). Her high school chemistry teacher informed her that her gender would prevent her from making it in chemistry. Colwell ended up at Purdue, refrained from the pursuit of cooking in order to balance equations, and benefitted by the encouragement of a woman professor, atypical in the 1950s. During this same time period, Colwell was blatantly told that a fellowship would not be wasted on a woman. Colwell has created her own symbolic slant on the glass ceiling metaphor. She prefers to use the symbolism of a crystal ball providing clarity of vision and abundance of futures

rather than the metaphor of a glass ceiling which might not be able to withstand the weight of what needs to be learned and changed. She asserts that the path is still long in the journey to achieve equity in all aspects of scientific and engineering education and careers. Regardless of the metaphor, various metrics support this assertion as they reveal a duality of progress for women and the continuing existence of a glass ceiling effect.

The duality of progress. The United States Equal Employment Opportunity Commission (EEOC) contends that glass ceilings can be considered a special type of occupational segregation (2004). In a look back, the 2004 report to Congressional Requesters by the United States Government Accountability Office (GAO) refers to extensive discrimination against women that existed 40 years ago, citing college admissions and employment as two representative instances. Evidence suggests that this segregation is still of concern in the beginnings of the 21st century, though progress is apparent in the business world. An appraisal of the changing composition of the workforce confirms that women are more prevalent and have higher status since the Civil Rights Act of 1964 that prohibited employment discrimination (GAO; EEOC). Similar progress has been seen in educational organizations. The academic world was affected when Title IX of the Education Amendments of 1972 provided protections to students and faculty by prohibiting discrimination on the basis of sex in education programs and activities benefitting from federal financial assistance.

Another measure of progress can be seen in GAO (2004) highlights of the growing proportion of women participating in the sciences over the past three decades, particularly in life sciences such as biology, with lesser increases at the graduate than the undergraduate level. However, the duality comes into view when considering status

measures. While there is a greater proportion of women faculty in the sciences, their salary and rank remain behind that of male faculty. Experience, patterns of work, and levels of education have been found to be contributory factors. However, studies reveal that discrimination might still impact women's choices and professional advancement. Ramifications of the glass ceiling go beyond the individual who has experienced it. When lesser qualified individuals fill positions, the negative effect extends beyond the employer to the entire economy (EEOC). From a leadership perspective, examined in greater detail later in Chapter II, having the right people in the right seats on the bus (Collins, 2001) is a crucial element to successful leadership and organizational success.

Visibility of women in academia. Women are present in college classrooms in increasingly higher numbers. The American Council on Education (ACE) data portray the shifting demographics in higher education (2006), with females having a 57% majority in total enrollment. It is instructive to note that what once was the traditional age for college attendance is no longer the case. Forty percent of undergraduates are 25 years of age or older. Among this population, women outnumber men almost two to one. While male enrollment in college has risen, it has not increased at the same pace as female enrollment. Both genders are earning increasing numbers of bachelor's degrees. ACE data also show that while men comprise 42% of total graduate enrollment, a male majority continues to exist in the following programs: MBA, noneducation doctorate, law, and Master of Science. In medicine, women are a slight majority at 51%. Gender gaps of significance in favor of women emerged in the middle to latter part of the 1990s. However, King, who authored the ACE study, concludes that women's gains have not come at the expense of men.

While the number of women who are earning degrees in science and engineering is increasing, the data show that increases have not translated into tenured faculty positions (American Council on Education, 2006; Lewin, 2004; Osellame, 2006). A report released by the National Academies (Committee on Maximizing Potential, 2006; 2006, September) highlights the shift from 40 years ago, when women comprised 3% of the American scientific and technical workforce, to 2003 when women are at almost 20% representation. The report indicates that more than 50% of bachelor's degrees in science and engineering have been earned by women since 2000. However, in the population of science and engineering Ph.D.s, full-time faculty positions are held by men by a four-to-one margin. A survey of the top 50 research universities in the United States ascertained that between 3% and 15% of full professors in top engineering and science departments are women (Lewin) and concluded that it is quite possible for a woman to obtain a bachelor of science without having been taught by a woman professor in her discipline. Hubka (2006) reported that female professors at the University of Oregon are in the minority in many mathematics and science departments, though women comprised 59% of the undergraduates in those departments in the fall of 2005. A student biology major quoted in his article considered her classes to be balanced or perhaps with a higher ratio of women, congruent with the University's data showing 61% of its biology students were women. While increasing the number of women faculty members in underrepresented departments may be of concern for some, this same biology major pointed out the lack of visibility for women already employed in such departments and also noted that she doesn't see their contribution.

While 61% of full-time professors in the United States are men, parity has been attained in terms of leadership at Ivy League universities, with half of the presidents now female following Harvard's appointment of Drew Gilpin Faust as the University's 28th president (Knight, 2007). In contrast, 2% of the American Fortune 500 companies have women CEOs and approximately 17% of the partners at large United States law firms are women.

Stereotypes. Stereotyping is essentially a process of categorization, frequently efficient and effective as a work-saving cognitive device to help us simplify and organize the complexity of our world (Heilman, 1997). Knowing attributes, for instance that knives are generally sharp and can cut things, precludes us from having to reestablish these attributes at each encounter. However, stereotypes pertaining to groups of people are frequently not accurate. These stereotypes can be overgeneralizations which have no applicability to an individual member of the group who may be targeted. Heilman notes that stereotypes pertaining to men and women are widespread and pervasive. The stereotyped traits not only are different but are valued differently. Data from a study of male managers discussed by Heilman support a strong influence of sex stereotypes on perceptions, even in the case when men and women are managers.

Heilman's (1997) lack of fit model strives to explore the role of sex stereotypes as an obstructer of progress for women in the corporate hierarchy. Her model, dating from 1983, suggests that personnel decisions are made upon how successful someone will be in working at a particular job. The perceived skills and orientation of the job's requirements and the perception of the individual's attributes that they would bring to the workplace create the performance expectations. If the fit is good, success will be

expected. However, if the fit is thought to be poor, the expectation is for failure. Heilman indicates that fit-derived performance expectations are central to the evaluative processes due to a cognitive tendency to perpetuate and confirm them. As filters, the expectations affect what is attended to, how it is interpreted, and what is remembered and recalled in the decision-making process. Using this model to examine the workplace, Heilman states that there is a lack of correspondence between the skills and attributes thought to be necessary for effective handling of male sex-typed upper management jobs and the attributes considered to characterize women as a group. She discusses four conditions that are often present in organizational situations that promote stereotyping and subsequent bias in decision making: (a) the relevance of sex has a direct relationship to the degree stereotypes will be part of forming impressions of any one particular woman, an issue when rarity of women in a context exists; (b) stereotypes thrive in vague performance settings, relevant in contexts with little quantifiable or objective metrics of success; (c) stereotypes are more likely to influence decision making the greater the decision-making process is unstructured; and (d) when performance cannot be indisputably credited to an individual, the use of stereotypes is enhanced, with success sometimes attributed to luck or other factors or to some other person.

Welle and Heilman (2005) discuss this issue of perceiving the workplace and the individuals who work within it as a matter of gender stereotypes. They distinguish between descriptive stereotypes, the group of traits and attributes perceived to uniquely describe men and women, and prescriptive stereotypes that refer to the set of attributes and traits that depict how men and women “should” be. Descriptive stereotypes, applied to those we come in contact with in the workplace, become the foundation for inferring

people's stable, internal characteristics. Even if little is known about an individual, the general category of man or woman provides a basis for inferring. Well and Heilman note that there is a simultaneous effect of the combination of people's cognitive representations of category-based traits and attributes and their normative beliefs about what is appropriate and inappropriate for each gender category that guides one's perceptions of people. The arena of politics exemplifies this effect: Miami Herald columnist Leonard Pitts Jr. (2007) took note when a woman asked Senator John McCain how they could beat the *bitch*, in reference to Hillary Clinton. McCain's response was to laugh. Pitts wondered if McCain would have laughed if it had been a racial slur instead of a stereotypical one. Pitts doesn't like Clinton himself, thinking she is cold, calculated, and brittle. However, that prompted him to reflect about other female national political figures. He perceives them all- Nancy Pelosi, Janet Reno, Condoleezza Rice, Madeleine Albright, as formidable, off-putting, and cold. His introspection led him to conclude that

> . . . the problem here is not so much them as me. And, if I may be so bold, we. As in, we seem unable to synthesize the idea that a woman can be smart, businesslike, demanding, capable, in charge, and yet, also, warm.... With the men, toughness reads as leadership, authority, getting things done. With her, it reads as 'bitch.' (p. E4)

Pitts points out that women pay a social price when the feminine traits such as nurturing, caring, and submission that we demand from them are not evident or are subordinate to drive, ambition, and competence.

It has been surmised that unconscious effects of stereotypes on thought and performance may affect testing outcomes, leading to research in the area known as

stereotype threat (Halpern, 2006; Smith, Sansone, & White, 2007). Halpern relates stereotype threat to the body of literature in self-fulfilling prophecies indicating that expectations of teachers or experimenters can unconsciously influence individuals' responses and how knowledge of that has led to medical researchers making use of double-blind, placebo-controlled crossover studies. Roeser, Peck, and Nasir (2006) describe stereotype threat as decrements in performance in specific achievement contexts among academically committed students who are members of groups that are targeted with stereotypes of intellectual inferiority. The effects entail tacit aspects of achievement situations such as those that emphasize relative ability/social comparison or race that implicitly initiate specific psychological contents and processes leading to decrements in performance. Roeser, Peck and Nasir (p. 412) indicate that the contents include psychological arousal or nonverbal anxiety, symbolic representations of stereotypes, identities as group members and of oneself that confirm a negative self-relevant stereotype, and iconic representations or fears of failure, viewing research into the dynamic relations among these aspects as potentially benefitting student outcomes.

Smith, Sansone, and White (2007) considered the issue of decreased motivation occurring as a result of competence-based stereotypes that can negatively affect women's performance in math and science. The researchers hypothesized that when working on a computer science task in mathematics, gender stereotypes would have a negative effect on undergraduate women's task interest, especially for women who had higher achievement motivation and were hypothesized to hold performance-avoidance goals in response to threat. Findings indicated that when compared to when the stereotype was nullified, when in the condition under stereotype threat, an assigned performance-

avoidance (as opposed to approach) goal was associated with lower interest for women higher in achievement motivation. Women higher in achievement motivation as opposed to those with lower achievement motivation were more likely to spontaneously adopt performance-avoidance goals. The researchers also found that task absorption primarily mediated the motivational influence of performance-avoidance goals under stereotype threat. Jamieson and Harkins (2007) conducted four experiments that support a mere effort account of stereotype threat, suggesting that the process is not negatively affecting the cognitive capacities of participants or leading them to withdraw their effort. Participants may be misdirecting their efforts while trying to disprove the negative stereotypes targeted at their group. Halpern (1997) acknowledges the significance of stereotype threat research in studying the effects of stereotypes due to the way it demonstrates the powerful, automatic, and unconscious influences stereotypes have on thought and performance.

Since the Sputnik era of the late 1950s, there is an increasing body of research literature regarding the ways in which students perceive scientists and their work. Mead and Metraux (1957) conducted the seminal work in this area with their study that analyzed a national sample drawn from 35,000 essays written by secondary students in response to questions regarding their thoughts about science and scientists. Findings from their pilot study indicated that students had an overwhelmingly negative perspective when it came to career choice or choice of a husband. The researchers provide a composite picture of how science appeared as a shared image in the essays:

> The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses. He is small, sometimes small and

stout, or tall and thin. He may be bald. He may wear a beard, may be unshaven and unkempt. He may be stooped and tired.

He is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials. The sparkling white laboratory is full of sounds: the bubbling of liquids in test tubes and flasks, the squeaks and squeals of laboratory animals, the muttering voice of the scientist.

He spends his days doing experiments. He pours chemicals from one test tube into another. He peers raptly through microscopes. He scans the heavens through a telescope [or a microscope!]. He experiments with plants and animals, cutting them apart, injecting serum into animals. He writes neatly in black notebooks. (pp. 386-387)

Mead and Metraux point out the little attraction that science had for young Americans, noting that they do not want to commit themselves to long-time perspectives, to dedication, to single absorbing purposes, to abnormal relationships to money, or to the risks of high levels of responsibility:

> The present trend is toward earlier marriage, early parenthood, early enjoyment of an adult form of life, with the career choice of the man and the job choice of the woman, if any, subordinated to the main values of life- good human relations, expressed primarily in terms of the family and of being and associating with the kind of human being who easily relates to other people. (p. 387)

Chambers developed an instrument for use in a 1983 study on the images of

scientists involving a sample of 4,807 elementary students, K-5, from Australia, Canada, and the United States (Thomas & Hairston, 2003), basing his test on the work of Mead and Metraux (Huber & Burton, 1995). Chambers' Draw-a-Scientist Test (DAST) requires students to draw their mental image of a scientist. Since its creation, the DAST has been administered to varied populations, including primary, middle, and secondary students and inservice teachers. The DAST incorporates seven indicators of the typical image of the scientist: (a) lab coat; (b) eyeglasses; (c) facial hair; (d) research symbols such as instruments and laboratory equipment; (e) knowledge symbols such as books and filing cabinets; (f) technology; and (g) pertinent captions, including formula, taxonomic classification, and eureka syndrome. The results of Chambers' study suggest that the indicators emerge as students advance in their grade levels, with most children including three or four indicators by fifth grade.

Huber and Burton (1995) highlight the gender aspects of Chambers' work. Only 28 of the 4,807 drawings were of females, all of which were drawn by girls. Huber and Burton cite additional studies with similar results, including one by Varney reported in 1989. In Varney's study, though 60% of the 1,600 responses from students in ages 2 through 12 were from females, only 135 drawings depicted female scientists and only 6 of those were drawn by males. In Finson's (2002) review of 50 years of the more relevant research on students' drawings and the perceptions they reveal reports similar findings from Flick's 1990 study of fifth-graders. Finson also reviews Rosenthal's 1993 study involving undergraduates, with few images of female scientists drawn by the participants. Thomas, Henley, and Snell (2006) suggest that the results of their study with college students indicate that either gender stereotypes are pervasively persistent even

among college science majors, or perhaps the DAST is not an especially sensitive measure in spite of its widespread use. In a study of the DAST with 675 Hong Kong Chinese students (2002), Fung found evidence that students developed a more stereotypic image of a scientist with age. A much greater percentage of students at all grade levels drew male scientists and drawings of female scientists were all drawn by female students. Fung suggests that future research should supplement the DAST with student interviews in order to obtain a greater understanding of student conceptions.

Psychobiosocial Perspective Summation

Halpern (2006) reminds us that it is highly unlikely that biology and environment/social factors can ever be separated into independent variables with their interaction separated from their main effects. She advocates rejecting the nature-nurture continuum in favor of the psychobiosocial model presented earlier in this chapter. Halpern stresses that learning is both an environmental and biological phenomenon since people are differently prepared for learning and also prepared by their own actions. An individual's own biology predisposes him or her to learn some skills more easily than others. Individuals also choose experiences in ways that are biased by prior learning experiences and their beliefs regarding appropriate behaviors for females and males. Stereotypes often reflect true group differences. Halpern suggests that by learning and endorsing those differences, people may in effect be also choosing environments that increase or decrease the differences. In pointing out that there is no evidence supporting a smarter sex, Halpern reminds us that test scores depend on the content of the test, with the philosophical question of the future being who gets to decide what content is important. The bottom line is that there are average differences that at times favor males

and sometimes favor females, deriving from what cognitive ability or content is being measured, the age at which it is being measured, and which cognitive process is required to solve the problems. Halpern emphasizes that all children can grow in each of these ability areas when provided with appropriate instruction.

Constructivism

Constructivism offers a productive framework to facilitate a deeper understanding of Dr. Mack's teaching and learning environments, experiences, and decisions. It is a theory about learning, not one about teaching (Fosnot, 2005a), that has relevance in both interpreting the learning environment and understanding the intent of the educator's practice. In line with the instrumental aspects of this study, the constructivist framework also provides a foundation for greater development of leadership implications.

The Nature of Knowledge and Knowing

Constructivism represents a paradigm shift in the viewpoint of the nature of knowledge and its development. Knowledge and knowing, according to the commonly accepted epistemological tradition of Western civilization, served the purpose of helping the knower to approximate some ultimate truth (von Glaserfeld, 2005). A logical conclusion from this paradigm would be the perception that knowledge is waiting for discovery as a fixed body of facts and exists independently of the knower. Behaviorism is a theory of learning that supports the view that knowledge is stable, objective, acquired by discovery through sensory experience and transmitted to the learner (Schraw, 2006). The instructional implications of this perception of knowledge and the learner can result in students being viewed as passive containers waiting to be filled. The teacher's role is one of filling the container with the knowledge he or she possesses in a curriculum being

covered. Extensive use of lecture in a teacher-centered classroom environment would be reflective of this perhaps implicit belief.

Advances in neuroscience techniques now allow us to perceive learning in live, awake brains rather than information deriving from studying brains during autopsy. These techniques allow scientists to discern the effect of experiential learning before it is observed as behavior (Bransford et al., 2006). While Bransford et al. highlight the gap between neurons and the chalkboard and the need for research that involves both educators and neuroscientists in the study of learning across contexts, the scientific advances of the 20th century have resulted in vastly different models used to describe and explain the world in the 21st century (Fosnot, 2005a; Rice, 2006). Changing models in biology, neuroscience, cognitive psychology, and epistemology have significantly altered the way we perceive the interconnected processes of teaching and learning. Constructivism as a framework reflects those changed perceptions of teaching and learning.

As an expansive conceptual framework in the realms of philosophy and science, constructivism encompasses many perspectives and related theories (Kearsley, 2007). Constructivism, with the view that knowledge is actively constructed, was initially controversial when it emerged as a theory in cognitive science (Fosnot, 2005a). While contemporary neurobiologists and cognitive scientists are mainly in agreement with the view that knowledge is actively constructed, the educational implications of constructivism are still controversial. Various instructional strategies, under the umbrella of constructivism, have been employed more or less successfully, including hands-on and discovery learning strategies. Fosnot points out that misinterpretation and confusion

regarding constructivism are prevalent and have resulted in attacks by the media, parents, and academic organizations.

Theoretical Underpinnings of Constructivism

The theoretical basis of constructivism derives from Jean Piaget's theory of assimilation and accommodation. Piaget broke from the commonly accepted epistemological tradition of Western civilization with the conception that knowledge does not have the purpose of representing ultimate truth (von Glaserfeld, 2005). The perception that knowledge serves an adaptive function distinguishes constructivism from other cognitive theories. Individuals interact with the environment, adapting through assimilation and accommodation, developing new conceptual structures as a result (O'Donnell, 2006). According to Piaget, ". . . all behavior is adaptive and that adaptation is always some form of equilibrium (stable or unstable) between assimilation and accommodation. . ." (Piaget, 1962).

Assimilation is not, as commonly interpreted, absorption of new information at a developmentally ready stage (Fosnot, 2005b). Assimilation does involve new experiences and objects and their relationship to existing cognitive structures. Individuals use their existing organizing schemes to "act on" a situation in order to make it similar to currently held cognitive structures. It is this "acting on" process that Piaget termed assimilation. Fosnot emphasizes that we know the world through the schemes and structures we employ to explore it, which leads to the core of constructivism. When presented with cognitive disequilibrium, or perturbations in Fosnot's terminology, individuals actively attempt to regain a state of balance, leading to revised conceptual structures reflecting new understandings. This cognitive reordering is the process of accommodation.

Cognitive disequilibrium or perturbations can derive from individuals' perceptions that their actions are ineffective or in the face of contradictory ideas.

Constructivism as a paradigm views learning as a recursive, non-linear building process incurred by active learners interacting in both physical and social environments (Fosnot & Perry, 2005). Piagetian and Vygotskian theories share a common emphasis regarding individual and social processes in a constructivist approach to teaching and learning (O'Donnell, 2006). Piaget never had the opportunity to meet Vygotsky, a colleague who was born the same year as he was born. Piaget expressed sadness that he became familiar with Vygotsky's work after his death, leaving no opportunity for them to reach understanding on several points (Piaget, 1962). In commenting on sections of Vygotsky's 1934 *Thought and Language*, Piaget found that he was more in agreement with Vygotsky on certain points at this later time than he would have been in 1934 and better prepared to argue other points with him. According to Vygotsky:

> Every function in the child's cultural development appears twice: first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of ideas. All the higher functions originate as actual relationships between individuals. (Kristinsdóttir, 2001)

A key component of Vygotsky's theoretical framework is the fundamental role of social interaction in cognitive development (Kearsley, 2007; Kristinsdóttir, 2001; O'Donnell, 2006). Vygotsky perceived that development incorporated cultural/societal and individual components, with a dialectical relationship existing between the child and cultural environment: "In the process of development the child not only masters the items

of cultural experience but the habits and forms of cultural behavior, the cultural methods of reasoning" (Vygotsky, 1929, p. 415). Another major aspect of Vygotsky's social development theory concerns the level of competency a learner can attain when supported by another, known as the zone of proximal development (ZPD). Adult guidance or peer collaboration leads to higher levels of skill development than what can be achieved by an individual. In line with Vygotsky's perception, the adult/child combination is most likely to foster cognitive growth (O'Donnell). O'Donnell indicates that adults are not always successful in knowing the current functioning of the learner and scaffolding the learning during this joint construction of the ZPD. Vygotsky (1926/1992) was cognizant of this challenge:

> Hence, the educator confronts two problems, first, the individualized study of all the particular traits of each individual student, and second, the individualized accommodation of all of educational methodology and all the effects of the social environment to every student.

Pedagogical Implications in Higher Education

Discoveries from research in the cognitive sciences, psychology, education, and other disciplines are driving a major pedagogical shift in higher education (Rice, 2006). Traditional pedagogical assumptions are being challenged by collaborative learning, experience-based learning, and technology. It is no longer perceived that faculty have the total responsibility for transferring knowledge. Hartle (2007) discusses the challenges faced by college science educators in evaluating lessons designed by others or in planning and evaluating action research. He notes the need for commonly held definitions and theories in order to cross disciplines and

effectively interpret diverse literature. Recognizing that true constructivism requires a great deal more than setting students loose to do what they choose, he delineates four criteria that are fundamental to identifying and assessing constructivism: (a) bringing forth prior knowledge, (b) generating cognitive dissonance, (c) application of new knowledge with feedback, and (d) metacognition, or reflection on learning. Determining prior knowledge provides a focal point for the learner to know what the lesson relates to and also assists the teacher in tailoring the lesson depending on the learner's current mental construct. In order for students to learn, they must recognize that their current constructs are insufficient or inappropriate to understand a concept. This recognition, known as cognitive dissonance, promotes students to modify their constructs (i.e. learn). Applying new knowledge then tests and adjusts the newly formed construct and reinforces it through repetition. Formative feedback is an essential component in this process. The last criterion, metacognition, helps the learner to both understand what was learned and how to approach new learning in a more informed way. Hartle's purpose in developing the above criteria was to support recognition of the theoretical, research-based essence of constructivism in applied, practical contexts. He proposes that use of his four identified fundamental criteria provides a framework for college science teachers to evaluate lessons, assess curriculum, and plan and evaluate educational research in concurrence with the principles of constructivism.

Constructivism and Student Engagement

The basic tenet of constructivism, learners actively constructing knowledge in physical and social environments, implies learning environments where teachers are

attempting to engage students in working on knowledge as opposed to passively absorbing it. Schlechty, in discussing the realities of the 21st century, notes that everyone must learn to work on and with knowledge, as it is no longer limited to the purview of intellectual elites (Sparks, 1998). He also proposes that the psychological bias of American educators leads to the assumption that observable behavior in schools results from a personality attribute, when individuals often act in response to structural and cultural forces. Since the focus of school should be on students' intellectual activity, Schlechty denotes the need for teachers to be skillful in creating work that engages students, as they will not learn from work they do not do. To Schlechty, good school work is compelling enough that students will persist in the face of difficulty and also derive satisfaction from its completion, while resulting in students learning things valued by parents, their community, and society in general.

Schlechty (Sparks, 1998) advocates shifting the focus from improving the teacher's performance in the classroom to improving the quality of work given to students to increase student engagement and subsequently improve performance. His Working on the Work (WOW) framework reflects ten areas of quality work: (a) a focus on product; (b) standards that are clear and compelling; (c) protection from negative consequences for initial failures; (d) affirmation of performance significance; (e) affiliation; (f) variety and novelty; (g) choice; (h) authenticity; (i) organization of knowledge; and (j) content and substance. Schlechty (2002) also addresses student responses to classroom work as a way to assess student engagement, outlining five ways in which students could respond to school tasks: (a) authentic engagement, (b) ritual engagement, (c) passive compliance,

(d) retreatism, and (e) rebellion. In offering a start to improving the quality of student work, he suggests that teachers develop a profile of their classrooms to understand the patterns of engagement in their classrooms. His sample student questionnaire on classroom engagement reflects the five response types and can be used to reveal engagement patterns. The resulting data can assist teachers in assessing the results and effectiveness of what they are currently doing.

Bowen (n.d.), following exposure to Schlechty's work, conducted a literature review to assess whether the literature concurs with Schlechty's position that quality work leads to increased engagement and improved performance. All the descriptions of research or practice that she surfaced in the literature regarding activities that engage students fit one of the ten areas of quality work reflected in Schlechty's WOW framework. She did not find any research that documented the degree of engagement associated with those ten areas and indicates the need for further research to document the effectiveness of the quality work areas to promote student engagement leading to school improvement.

The Center for Leadership in School Reform (CLSR) has also developed a process for collegial conversation regarding designing engaging instruction that draws upon the wisdom of the participants (Holland, n.d.). CLSR's five-step protocol was designed to facilitate focused conversations regarding the design of quality work for students. In the first step, the creator of the lesson informs the group what the students should know and be able to do following the learning experience (content and substance). In this step, the creator of the lesson provides a description of what the learning experience will look like. In the second step, colleagues ask clarifying

questions, followed by a third step in which the creator of the lesson provides a brief response to clarify the questions. Feedback from colleagues is offered during the fourth step. The creator ends the session in the fifth step with his or her comments.

Interactive and reflective approaches undertaken by teachers participating as learners in a community of practice can facilitate teacher understanding of the impact of meditational strategies on learning, with teachers redefining and reenacting pedagogies they've experienced to be effective. McGregor and Gunter (2006) found emerging evidence of teacher ability to alter their practice in an informed way to affect the culture and nature of learning. Secondary science teachers engaged in a two-year inservice program which situated them in the role of learners undertaking authentic tasks. Participants were guided in a reflective process on the ways in which the nature of social interactions can affect reasoning and meaning making. The use of authentic problems facilitated teacher understanding of how learning theories can be utilized in the classroom. Clarity regarding the interrelationships among thinking, talking, and learning was promoted through modeling mediation in differing ways and collectively objectifying the cognitive purposes of intersubjectivity. Through this process, teachers were then able to recognize and implement pedagogic strategies supportive of greater exploratory discourse that enhanced collaborative thinking and independent learning.

Potential Utility

In describing both what knowledge is and how one comes to know, the broad framework of constructivism offers practical insights into ways in which individual learners and communities of learners can intentionally engage in determining what

individual and group knowledge exists, assess the utility and validity of existing knowledge, continually build and reconstruct that knowledge, and clarify to what degree that knowledge is "shared" (von Glasersfeld, 2005). Constructivism as a framework holds potential for helping learners and organizations interpret learning environments and create more effective ones to facilitate continual learning to successfully navigate the demands of our emerging global environment.

Creativity

The biological foundation of constructivism relates to a new biological model which is no longer limited to simple genetic determinism, with new cells produced from naked DNA (Fosnot, 2005a). The model now involves entire cellular networks that are living, evolving systems which are organizationally closed but materially and energetically open. Fosnot refers to Nobel laureate Ilya Prigogine's description of cellular structures as dissipative, emphasizing the interplay between maintenance of the organization of the structure of the cell and the flow and change (dissipation). Increased energy flow can yield a bifurcation point (a point of instability) resulting in a totally new form of order. The significance of this new biological model is emphasized by Capra (as cited in Fosnot, 2005a, p. 277):

> This spontaneous emergence of order at critical points of instability is one of the most important concepts of the new understanding of life. It is technically known as self-organization and is often referred to simply as "emergence." It has been recognized as the dynamic origin of development, learning, and evolution. In other words, creativity- the generation of new forms- is a key

property of all living systems. . . . Life constantly reaches out into novelty. . . .”

Constructs of Creativity

In 1950 J. P. Guilford’s presidential address to the American Psychological Association spotlighted the over-looked but significant field of creativity and set off a torrent of related research, which also fueled a great deal of public interest in creativity (Haring-Smith, 2006; LaChapelle, 1983). Guilford noted that only 0.2% of the Psychological Abstract entries before 1950 concerned creativity. The field of creativity has continued to inspire great debate amid the proliferation and evolution of definitions and theories (Amabile, 1993; Clark & Mirels, 1970; Csikszentmihali, 1993; Runco, 1993; Stanley, 1956; Sternberg, 1996; Sternberg & Lubart, 1993). Greenfield et al. (2006) define a cultural concept of creativity as the desirable outcome of a creative process and illustrate the shift from a community definition of creativity to an individual one reflecting differentiation and innovation.

In his review of Sternberg’s edited collection of essays on the nature of creativity, Pariser (1993) found that the themes of process, person, product, and place were of greatest utility. Creativity as a process includes the conception of models and images that alter external and internal worlds while effectively bridging knowledge gaps, continual reframing and modification of specified problems, utilization of broad themes and images in comprehending the current problem, and some degree of tension. Pariser discusses Sternberg and Tardif’s summation of researcher agreement in the discussion of person and product themes. Creativity perceived through a person lens finds general agreement on several attributes. Creative individuals commonly

possess a high IQ, originality, articulateness, and imagination. They handle novelty well, form independent judgments, and perhaps are better at identifying than solving problems. Other traits associated with creative people include their willingness to take risks, perseverance, and curiosity. They may be reflective in nature, possess a high degree of motivation, and are likely to experience conflict somewhere in their personal lives or in interactions with their social environment. Qualities identified by Sternberg and Tardif that may be common to creative products include uniqueness, parsimony, and a lasting impact on either a domain or social environment. Important creative products in the realm of science address knowledge gaps and may be difficult to classify at first because of their interdisciplinary nature. They are unexpected and include a synthesis of wide-ranging domains of knowledge. The theme of place or context is polarized, with some researchers holding for a creativity that exists without consideration of time and place and others observing that creativity is a socially constructed term with no existence beyond the context of time and place.

Joseph Dillon Ford (n.d.) addresses this issue in taking exception to Gardner's theory of creativity that involves a person's talents, the area in which the person is attempting to be creative, and the culture evaluating the outcome. Ford takes the philosophical question regarding whether or not a tree falling in the forest makes a sound if no one hears it and constructs a parallel question that asks whether or not a score created by a composer has value if no one else hears it. Ford acknowledges the professional benefits to being recognized, but points out that external standards of originality are implicit in the term recognition, with outcomes that are not congruent

with a standard remaining obscure. Ford considers recognition based on external judgments of what is and isn't creative as a potential barrier to understanding.

Eysenck (1995) purports that creativity is closely related to gender and that genius is almost without exception a male attribute. Csikszentmihalyi (1993) finds amusement in Eysenck's referral to the paucity of women in *American Men of Science.* He points out that Eysenck prefers to interpret facts through the lens of lesser levels of psychoticism in females rather than reflections of the social construction of creativity. Csikszentmihalyi reminds us that such social construction largely determines the type of individuals who are acknowledged as potential contributors. According to Csikszentmihalyi, any search for creativity focusing on the head, DNA, or hormones is predestined to fail because a relation cannot be discovered through analysis of one of its elements. He believes that any model attempting to represent the creative process in its entirety will have to get beyond the restrictions of earlier psychological approaches which have a person-centered perspective.

David Perkins, former Harvard Project Zero co-director, has a long-standing interest in creativity:

> I've been thinking and writing about creativity for many years. In the early 1970s, creativity emerged for me as a major area of interest- one of several that I pursued- and I began to do systematic research on the nature of creativity and the psychological factors underlying creativity. *The Eureka Effect* is the latest expression of that interest. (Graff, 2001)

In *The Eureka Effect*, Perkins defines breakthrough thinking as a type of creativity incorporating out-of-the-box thinking which leads to fundamental discovery or

invention in any context. He makes the argument that such fundamental discovery or invention is discrete from typical problem solving, with very unique patterns of thinking. Perkins' *The Mind's Best Work*, written earlier, and *The Eureka Effect* comprise Perkins' central writings on creativity. A lesser-known model of creativity was suggested by Perkins several years ago as a reasonable and helpful account (personal communication, November 13, 2007). This six-trait snowflake model of creativity conceptualized the facets of an individual's creativity as: (a) problem finding, (b) objectivity or openness to the views of others, (c) working at the edge of one's competence, (d) intrinsic motivation, (e) aesthetic orientation, and (f) mental mobility (Ford, n.d.). Ford takes exception to Perkins' snowflake model, believing it lacks the essence of artistic creativity and reflects characteristics of many individuals who excel in their fields but may not have this essence.

Creativity and Intelligence

Creativity and intelligence are not synonymous, though research indicates a high degree of intellectual ability, as measured by IQ tests, is found in the presence of exceptional creative ability (Moore, 1966; Pariser, 1993). Moore references several studies in concluding that creativity is typically associated with above-average intellect, including a study sponsored by the Carnegie Corporation which suggested creativity depends upon some amount of intelligence, though it is not significant beyond an IQ of 120. The relationship between creativity and intelligence is not necessarily reciprocal, as individuals possessing high IQs may or may not be creative. Individuals vary on both intellectual and performance continuums, yielding a complex set of phenomena that theories of intelligence endeavor to clarify and

organize (American Psychological Association (APA) Task Force on Intelligence, 1995). Continuums noted by the APA Task Force include: (a) comprehending complex ideas, (b) adapting to the environment, (c) learning from experience, (d) reasoning, (e) surmounting obstacles, and (f) consistency of performance in differing contexts evaluated with varying criteria.

Two theories of intelligence that take into account the complexity and variation of individual abilities and performance offer particularly valuable contributions in the exploration of Dr. Mack's life, attributes, accomplishments, and challenges- Howard Gardner's theory of multiple intelligences and Robert Sternberg's triarchic theory.

Gardner's Theory of Multiple Intelligences

Howard Gardner's intrinsic interest in the arts and professional experiences in a neuropsychological unit attempting to comprehend the ways in which human abilities are organized in the brain set the stage for his eventual segue into a theory of multiple intelligences (Gardner, 2003). His challenge as a participant in a 1979 grant-funded project on human potential was to write a book about the state of knowledge regarding human cognition deriving from scientific discoveries in the biological and behavioral realms. This opportunity allowed him to synthesize his work on brain damage with a study of cognitive development. An epiphany during this process led him to use the term multiple intelligences to describe particular human capacities. Constant reframing of his learning evolved into eight criteria and a definition of what is and isn't an intelligence. Gardner's theory argues against the construct of a single intelligence. He claims that individuals possess a set of somewhat independent

intelligences, ranging from musical, bodily-kinesthetic, interpersonal, and intrapersonal to the more commonly known spatial, linguistic, and mathematical abilities. Though all of us possess these intelligences, Gardner maintains that differences in genetics and experiences contribute to the variations in our individual profiles of intellectual strengths and weaknesses. Gardner also reaffirms that his theory of multiple intelligences does not have direct educational implications, though he believes it is sensible to consider differing intellectual profiles in educational system design. Gardner concurs with the APA Task Force (1995) that assessing the domains of his theory is not easily done. The Task Force also highlights the debate on whether some of Gardner's domains are more appropriately labeled special talents rather than types of intelligences. Gardner discusses the advances made in the biological sciences and his interest, had he the time, to reexamine the nature of intelligence.

During the 1990s Gardner (2003) broadened his range of multiple intelligences by incorporating a naturalist intelligence and the potential for existential ("big questions") intelligence. In this time period he also engaged in case study research of individuals with extraordinary intelligence profiles (Gardner, 1993; Gardner, 2003): (a) Sigmund Freud, intrapersonal; (b) Albert Einstein, logical-mathematical; (c) Pablo Picasso, visual-spatial; (d) Igor Stravinsky, musical; (e) T.S. Eliot, linguistic; (f) Martha Graham, bodily-kinesthetic; and (g) Mahatma Gandhi, interpersonal. Graham, as the sole female case study depicted in Gardner's *Creating Minds*, experienced the barriers of prevailing attitudes and expectations in a creative milieu dominated by males.

Gardner's creativity framework (1993) is based upon the relationship among three fundamental elements: (a) the individual both as child and master, (b) the work and domain the individual engages in and affects, and (c) the other people in the individual's world. In exploring the relationship between the child and the master, Gardner makes the case for a special combination of the childlike and the adultlike as a significant attribute of creativity. He cites Freud's consciousness of the child, Einstein's curiosity, Picasso's desire to control, Stravinsky's litigious nature, Eliot's love of puzzles, Graham's behavioral patterns, and Gandhi's excessive interest in bodily functions as examples. Gardner is attentive to how his creators master, work in, and eventually revise the nature of their domains. In the area of relationships, Gardner examines the degree and kind of mentoring that his population had. Freud experienced strong father figures, including Bruecke, Charcot, and Breuer. Stravinsky benefited from his relationships with Rimsky-Korsakov and Diaghilev. Gardner's population also experienced fairly dismal, turbulent relationships with others. The bottom line for creative activity, according to Gardner, is "that all creativity grows, first, out of the relationships between an individual and the objective world of work and, second, out of the ties between an individual and other human beings" (p. 9).

Sternberg's Triarchic Theory

Robert Sternberg defines intelligence as "your skill in achieving whatever it is you want to attain in your life within your sociocultural context by capitalizing on your strengths and compensating for, or correcting, your weaknesses" (Plucker, 2007). His initial interest in human intelligence derived from his own issues with poor performance on IQ tests during his elementary schooling that fostered low

expectations for his future performance from his teachers. His proclivity in the field perhaps could be foretold by his 7th grade science project, the creation of his own intelligence test.

Sternberg's triarchic theory of intelligence (APA Task Force, 1995; Plucker, 2007; Sternberg, 1996) suggests that there are three essential components of intelligence with a need for balance among them: analytical, creative, and practical abilities. Analytic intelligence can be assessed by tests and involves problems that are clearly defined by others. Analytic problems can be devoid of intrinsic interest and come with all the requisite information needed to solve them. On the other hand, practical problems often need to be recognized in the first place and require additional information. They are enmeshed with everyday experience and prior knowledge and can have multiple satisfactory solutions. Studies done by Sternberg and his colleagues in the realm of practical intelligence and tacit knowledge reveal that tacit knowledge is a reasonably good predictor of job performance in spite of being fairly independent of IQ scores (APA Task Force). Adaptability is a key aspect of Steinberg's theory as the individual both maximizes strengths and compensates for weaknesses within a particular sociocultural environment.

Sternberg and Lubart (1993) believe that creative performance derives from the interactions of six resources: (a) facets of intelligence, mainly the capacity to redefine problems and think insightfully; (b) knowledge of the domain, particularly while maintaining flexibility to view problems in novel ways; (c) styles of thinking, including enjoying devising new problems and rule systems, usually with a global viewpoint; (d) personality, frequently including tolerance for ambiguity, the ability to

face and overcome adversity, openness to growth, willingness to engage in reasonable risks, and belief in oneself; (e) motivation, intrinsic and task focused; and (f) environment, particularly one that supports and rewards creative thought and values one's particular contributions. In addressing the relationship between intelligence and creativity, Sternberg and Lubart identify the ability to redefine problems and think insightfully as the particular aspects of intelligence that are germane to creativity. Selectivity plays a key role in the insight skills that assist in the redefinition of problems. Selective encoding is used to determine which information is relevant to the problem or its redefinition. Selective combination is used to assemble puzzle pieces whose connections are obscure. Selective comparison comes into play in the recognition of the applicability of old information to the solution of a new problem when the significance is not readily apparent.

The Ten-Year Rule

The ten-year rule was first articulated and researched by Hayes (Gorny, 2007; Bereiter & Scardamalia, 2006). In many fields of endeavor, significant creative outcomes are not produced prior to 10 years of work and study in a particular domain. Gardner (1993) found evidence of this ten-year rule in his study of creative individuals. Most of his population approximated the ten-year pattern, with a beginning decade of domain learning, another decade leading to a dramatic breakthrough, and yet another decade before an additional major culminating work emerged. Freud's work on dreams took place nearly a decade following his original apprenticeship in Charcot's laboratory. Gardner's study of T. S. Eliot also revealed this pattern, as Eliot wrote "Prufrock" while in his early twenties and a decade later

penned *The Waste Land*. Others in Gardner's population, Graham (who believed it took ten years to develop a dancer), Picasso, and Stravinsky, exhibited several ten-year regeneration cycles. Sawyer (2007), in the process of concluding that collaboration is the secret to breakthrough thinking, conducted a ten-year study of group improvisation, perhaps not only experiencing an epiphany but also exemplifying the ten-year-rule pattern! Bereiter and Scardamalia surface issues regarding the dichotomy between the general education and development emphasized in schooling and the implications for the ten-year rule that show the significance of goal-directed work in a specific domain. Along this line of thought, idea improvement, depth of understanding, and design mode curriculum may be more important in developing creative talent than trying to teach creativity. Bereiter and Scardamalia refer to Sternberg's position that creative careers emerge from a decision to be creative, to pursue specific types of creative goals within a selected field, and the development of necessary abilities as a possible catalyst for replacing the teaching of skills relating to generating ideas to setting students on paths that will lead them to creative outcomes in their selected endeavors. In essence, the ten-year rule highlights the significance of widespread domain-specific knowledge and purposeful practice for success in creative performance (Gorny).

Vygotsky Revisited

Dialectical tension and creativity. Dr. Seana Moran, one of Dr. Gardner's former doctoral students who is currently at Stanford, is particularly interested in the creativity of women (Gardner, personal communication, November 5, 2007). Moran suggests that Vygotsky's cultural-historical theory which emphasizes the active role

of an individual's social and cultural environment in development and his writings pertaining to creativity and imagination have relevance for this study (Moran, personal communication, November 5, 2007). Vygotsky's learning theories found support in the educational community, but his scattered and less cohesive concepts of creativity did not find the same level of receptivity (Moran, 2008; Moran & John-Steiner, 2003). Moran and John-Steiner examined Vygotsky's contributions to the dialectic of development and creativity. Vygotsky perceived that creative work is intensely social, viewing the creative process as "interaction, tension, transformation, and synthesis over the parallel timescales of the creative act, the creative life, and historical cultural development" (p. 62). The authors note that Vygotsky's focus on the transformational construction of the new has much in common with complex system approaches that are emerging through work in computer modeling, indicating that Vygotsky's work from more than seven decades ago is contemporary and relevant.

Moran and John-Steiner (2003) concur with Vygotsky that "creativity is fundamental to the development of all individuals, and through the study of the interweaving of creativity and development, people's true natures are revealed" (p. 63). In examining the dialectic of development and creativity, Moran and John-Steiner present Vygotsky's conceptualizations of internalization and externalization. To Vygotsky, developmental and creative processes were thought of as appropriation of cultural tools and social interaction, depicted as internalization, or a process of transforming or reorganizing incoming data and mental structures based on an individual's characteristics and prior knowledge. The individual personality, a

typical manner of behavior that constrains subsequent activity, is the dynamic form resulting from this process. Externalization, the construction and synthesis of emotion-based meanings and cognitive symbols, is what Western psychology typically refers to as creativity. Meanings and symbols are incorporated in creative products or cultural artifacts that survive over time for use by those in the future. Materialized meanings, derived from shared ideas, beliefs, knowledge, emotions, and culture are the dynamic constructions resulting from externalization. Moran and John-Steiner emphasize the dialectical tension that comes from both of these social processes, internalization and externalization, and both symbol-based forms, personality and culture. The tension provides a fertile basis for creative products and novel ideas, with development and creativity interdependent. The connections are complex and cyclical, as depicted in a visual map by the authors (p. 64).

Role as a lens. Moran (2008) revisits the study of creativity that has seemingly coalesced into studies based on four components, or 4 P's (person, process, press, and product), in offering a systems approach founded on role theory for an interactive examination of the 4 P's. Moran notes that Vygotsky's ZPD, discussed earlier in Chapter II of this study, was a systems model that was mainly perceived in light of the individual learning from the culture. The idea that the ZPD was a venue for the culture to learn from the individual did not take hold. In Moran's systemic examination of creativity, creativity is "a novel yet appropriate outcome of the interaction of individual, field, and domain that influences the way others in the field use domain resources" (p. 3), with correspondence to the 4 P's: individual-person, field-press, domain-process, and outcome-product. Instead of focusing on the 4 P's as

independent elements, Moran's system model places an emphasis on their interactions: Creativity involves influence of the individual on the domain in its impact on the thoughts or behaviors of others. Field-domain interaction occurs through the change in how people think. Individual-field interaction takes place since creativity requires the thoughtful evaluation of knowledgeable others. Relating to the earlier discussion in this chapter of Halpern's psychobiosocial model, Moran also notes the study of isolated elements, in this case the individual, field, and domain.

Moran (2008) posits utilizing the concept of role as a lens to support a focus on the interactions of elements. Roles encompass the predictable behaviors of individuals depending on their knowledge or beliefs and their social context in terms of identity and power in relationship to others. Moran points out that creativity is often considered an aberration from the performance norm in well-specified roles or as an aberrant role typology. It is the role, the intersection of person, field, and domain demands, which provides the potential for creativity to transpire. In a discussion of conventionalized work in a particular time in history, Moran notes the confusion that can result when work in a domain is produced that does not have current field approval. The worth of the work as perceived by the field is not readily apparent, and if it is truly unique, criteria might not even exist for judging its value. Over time the novel work will either be evaluated as faulty, with the existing field-domain alignment staying intact, or it will be considered creative, possibly transforming the domain. Creativity is found in the dynamics of the misaligned-then-realigned condition. Moran also indicates that the role view highlights creativity as an evolutionary rather than revolutionary phenomenon. Each individual in a job interacts

on a daily basis with the field and domain via the social and symbolic dimensions of the role. Moran observes that the role view suggests that a strong relationship between the individual and the social/field results in outcomes that are more conventional, whereas a strong relationship between the individual and symbolic/domain has a greater likelihood of producing more creative outcomes.

Organizational Implications

Creativity plays a crucial role in innovation, inducing new programs, products, and services (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Farooq, 2004), with numerous researchers proposing that creativity is as crucial to organizational survival in the long-term as it is in fields like science and the arts (Unsworth, 2001). Indeed, given the accelerating pace of change in the 21st century, it would be prudent for employers and their management teams to focus on assuring that employees can fulfill the creative expectations of their jobs (Shalley, Gilson, & Blum, 2000). In a study designed to validate an instrument for measuring perceived stimulants and obstacles to creativity in organizational workplaces, Amabile and her colleagues identified aspects that might be significant in influencing creative behavior in organizations: challenge, organizational encouragement, work group supports, supervisory encouragement, and organizational impediments. Challenge and work group supports were found to have the highest effect sizes in two phases of their study, while their results suggest that resources, workload pressures, and freedom play lesser roles in organizational creativity. Shalley, Gilson, and Blum's study on how organizations can manage creativity through work environment structures that complement the creative demands of jobs found self-reports of higher satisfaction and

lower plans to leave when individuals' work environments complemented the creativity demands of their jobs. In their study, jobs demanding a high level of creativity were also relatively high on complexity, autonomy, and demanding work and comparatively low on organizational controls. The researchers suggest that the congruence of job demands and the structure of the work environment might be significant for positive psychosocial outcomes.

Zhou and George (2001) wondered whether job dissatisfaction might have a positive rather than negative impact on organizational effectiveness and what conditions would result in creativity as an expression of voice. They review the research and theory in identifying four ways in which employees react to job dissatisfaction: (a) exit, an active strategy in which the dissatisfied employee decides to leave the organization; (b) voice, also an active strategy, whereby the dissatisfied employee decides to stay in the organization and engage in endeavors to improve conditions; (c) loyalty, a passive reaction in which the employee determines to remain and does not offer objections or ideas for improvement; and (d) neglect, also a passive reaction, whereby the employee stays with the organization and exhibits behaviors such as reduced effort. Three of these responses have potentially negative ramifications for organizations. Employee departure and passive responses lead to a reduction in important human resources, do not address and solve any valid problems, and can maintain or spread the dissatisfaction.

Employees who remain with their organizations due to necessity such as economic or opportunity factors exhibit continuance commitment, which is a likely precursor to transforming job dissatisfaction into creative results through voice. Zhou

and George (2001) found that employees with high job dissatisfaction and high continuance commitment displayed the highest creativity when one of three conditions was present: (a) helpful feedback from coworkers, (b) assistance and support from coworkers, or (c) when perceptions of organizational support for creativity were high. They propose that organizations may be able to guide employee dissatisfaction into creativity by making sure that one of these three factors is in operation. In exploring Dr. Mack's life, career, and challenges, the presence or absence of these factors was informative to interpreting her decisions and outcomes. The factors are also highly relevant to current and future challenges for organizations.

Leadership

Examination of leadership from a number of perspectives is fundamental to understanding the contexts in which Dr. Mack worked, including her interactions with others, her behaviors, choices, productive output, and influence on others. The instrumental nature of this case study draws upon the leadership literature in supporting a forward look to leadership in 21st century STEM fields.

Overview of Leadership Theory

The majority of Dr. Mack's life spanned the first two periods of the scientific study of leadership delineated by Chemers (1984/1995): (a) 1910 to World War II, the trait period; (b) from the start of World War II to the late 1960s, the behavior period; and (c) from the late 1960s to the present time, the contingency period.

Trait theory. Trait theory derived from the notion that leaders were in some way different from other individuals and possessed qualities which could be identified through personality tests. Great man leadership theories enjoyed popularity

and generated controversy; great men were born rather than made, in a time period where practically all leaders in business were men (Kirkpatrick & Locke, 1991/1995). Heifetz (1994) reminds us that women were not even possible candidates when it came to greatness. History was considered the story of great *men* and the impact they had on society. Stodgill's (1948/1995) review of more than 120 trait studies did not reveal a cohesive and reliable trait pattern, leading him to predict that leadership theories would be insufficient without the addition of personal and situational characteristics.

> The findings suggest that leadership is not a matter of passive status, or of the mere possession of some combination of traits. It appears rather to be a working relationship among members of a group, in which the leader acquires status through active participation and demonstration of his capacity for carrying coőperative tasks through to completion. Significant aspects of this capacity for organizing and expediting coőperative effort appear to be intelligence, alertness to the needs and motives of others, and insight into situations, further reinforced by such habits as responsibility, initiative, persistence, and self-confidence. (pp. 131-132)

In spite of the numerous scientific studies that have discounted the trait approach, it saw a revival in the 1980s and continues to spark popular debate (Heifetz, 1994). Kirkpatrick and Locke (1991/1995) discuss the resurgence of trait theory and research that reveals evidence supporting the existence of particular core traits that are contributing factors and preconditions for leadership success in business. Preconditions alone will not lead to success- to be successful, leaders must

act. According to the authors, evidence shows there is a difference in six traits between leaders and non-leaders: (a) drive, which reveals a high degree of effort and incorporates achievement motivation, ambition, energy, tenacity, and initiative; (b) desire to lead, including motivation to influence others and perhaps involving a need for power; (c) honesty/integrity, with a correspondence between words and actions; (d) self-confidence, important to decision making and earning the trust of others; (e) cognitive ability, requisite for the analysis and synthesis of large quantities of information; (f) and knowledge of the business, needed to make informed decisions and comprehend their implications. Kirkpatrick and Locke are of the belief that the individual does matter and leaders need to have the "right stuff," which is not equally found in all individuals.

A variation on trait theory seems to have emerged from Collins' *Good to Great* study (2001). In researching how companies progress from competence to greatness, Collins and his team determined that what they called Level 5 leadership is a requisite for greatness. Level 5 leadership traits, which Collins believes are prevalent if we are aware of what to look for, include a paradoxical combination of personal humility and professional will. Level 5 leaders have the ability and desire to ensure the success of the individuals who will take over the helm when they depart. They are self-effacing and modest. Level 5 leaders are also driven and have a need to produce sustained results. Collins refers to them as more plow horse than show horse in their work ethic. When things go well, they give credit to others. When the opposite occurs, they accept the responsibility and blame themselves.

Behavior theory. Studies of leader behaviors became popular after the lack of success with the trait approach and given the increasing emphasis on behaviorism in psychology (Chemers, 1984/1995). Research by Lewin and his colleagues defined leadership through behavioral style: autocratic, democratic, and laissez-faire. A shift in the 1950s led to an exploration of what leaders do, with a comprehensive study of leader behavior revealing two significant behavioral factors: consideration and initiation of structure. Another way of framing these important aspects of leader behavior is task versus relationship (Hersey & Blanchard, 1979/1995). Task-oriented leaders focus concern on task outcomes and usually behave in ways that are more structured, directive, and perhaps autocratic. Relationship-oriented leaders focus on interpersonal dynamics, avoidance of conflict, and keeping morale high with more participative and considerate behaviors (Chemers). Initially thought to be either/or styles of leader behavior, task and relationship were viewed as a dimension on a single continuum that varied from highly authoritarian or task leader behavior on one end to highly democratic or relationship leader behavior at the other end.

Leadership studies at Ohio State in the mid 1940s evolved the task-relationship continuum into a four-quadrant model, followed by the work of Blake and Mouton that placed five leadership types founded on concern for production (task) and concern for people (relationship) on the quadrants. Unfortunately, this approach suggested the existence of a best style of leadership while no universal has been discovered. Hersey and Blanchard (1979/1995) discuss research studies conducted by Korman, Fiedler, and others that suggest that different leadership styles are required as the context varies. Though behavior patterns were identified during

the behavioral theory era, they did not show a consistent relationship to group productivity or follower satisfaction, important organizational outcomes. Neither the task era nor the behavior era yielded the best or ideal style of leadership.

Contingency theories. Given that empirical studies did not find a particular collection of traits to be associated with leadership, theorists started to synthesize trait theory with behavior theory in suggesting that varying situations call for different personalities and behaviors (Heifetz, 1994). After fifteen years of extensive studies, Fred Fiedler concluded that leadership style was not sufficient to explain leadership effectiveness and proceeded to create a model that added situational parameters to the leadership formula (Chemers, 1984/1995). Fielder's scale of situational control is founded on three aspects of a situation: (a) leader-member relations, or the amount of trust and support that followers give to the leader; (b) task structure, or the clarity with which goals and procedures are specified; and (c) position power, or how much formal authority the leader has to reward and punish followers. As these aspects vary, different leadership styles are more or less effective. Fielder's theory, known as the Contingency Model, has generated a great deal of controversy. Chemers refers to extensive research on this model and notes that data from both laboratory and organizational studies strongly support the predictions of Fielder's theory. Results from Contingency Model research on the outcomes of leadership training indicate that facets of certainty, predictability, and control might be the most crucial factors in the leadership formula. Fielder's model and other contingency theories are based on the assumption that there is no such thing as one best way to make decisions and the aspects of the situation will determine which leadership style will be most effective.

Transactional and transformational theories. Leadership theories have evolved from a singular focus on the leader and the leader's behaviors and traits to an examination of the interactions and relationships between the leader and his or her subordinates or followers (Chemers, 1995; Heifetz, 1994). Transactional theorists offer the view that authority derives from reciprocal relationships in which leaders influence followers and followers also influence leaders. Chemers stresses the importance of Hollander's research in leadership. Hollander's studies reveal that leadership legitimation involves a process of social exchange, where group members provide their competence and loyalty and receive group-mediated rewards in return that can include tangibles such as income or protection to less intangibles such as status and influence. Another variation on transactional theory as discussed by Heifetz portrays bargaining and persuasion as the core of political power, necessitating an acute understanding of stakeholder interests. In transactional leadership, relationships do not progress beyond the bargain and the related purposes of the parties; with no enduring purpose to sustain the leader and the follower, they may part ways after the leadership act (Burns, 1978/1995).

Heifetz (1994) suggests that we might be better served if we stop defining leadership as an authority position in a social structure or in terms of a personal set of attributes and characterize leadership as an activity instead. This perspective permits leadership from many positions in a social structure, with personal abilities becoming resources for leadership that can be applied in various ways in differing contexts. With leadership portrayed as an activity or mobilization of people to do something, the issue becomes one of determining the nature of that socially useful outcome.

James MacGregor Burns expounds upon the distinction between transactional and transformational leadership (Burns, 1978/1995; Heifetz, 1994). Transformational leadership takes place when individuals engage with others in ways that leaders and followers elevate each other to higher levels of motivation and morality. Objectives that may have been disparate at one time, typifying transactional leadership, become welded and power bases become mutually connected for a common purpose. Burns depicts morality in view of human development and a hierarchy of human needs, drawing upon the work of Lawrence Kohlberg, Erik Erikson, and Abraham Maslow (Couto, 1993/1995). Higher human needs are taken into account and fulfilled when a group of individuals progresses from one stage of development to another one through the support of transformational leadership. Couto notes that in spite of the clear message from Burns that transformational leadership is not heroic and not executive leadership, the majority of applications of Burns' work has been to those types of leadership.

In a perspective on transformational leadership in businesses, Rolls (1995) addresses the pressing economic issues facing organizations that have converged with sociocultural changes whereby employees want to define their lives and works by their terms. Individuals want to enjoy work, contribute, be respected, learn, and grow in organizational environments traditionally not responsive to the needs of workers. Today's leaders need to address organizational transformation issues of personal growth, vision, trust, and creativity in leading cultural change. In today's organizations, Goleman, Boyatzis, and McKee (2002) suggest that the foremost job of leadership is driving collective emotions in a positive direction and eradicating the

smog resulting from toxic emotions. They refer to the ability of visionary leaders to uplift the emotional climate of organizations and transform its spirit at many levels, noting that the visionary style comes naturally to transformational leaders who are attempting to radically change an organization. Transformational leaders, according to Rolls, exemplify Senge's five disciplines (Senge, 1990): (a) systems thinking, (b) personal mastery, (c) mental models, (d) shared vision, and (e) team learning. Leaders who have experienced their own transformation are prepared to lead others in this endeavor. The leadership qualities most needed in this process, and least available, include integrity, vulnerability, awareness of the human spirit, courage in relationships, and tolerance for ambiguity.

In looking at transformational leadership applications to school settings, Liontos (1992) discusses Leithwood's findings regarding fundamental goals pursued by transformational leaders: (a) facilitating and maintaining a collaborative and professional school culture; (b) promoting teacher development; and (c) helping teachers to develop more effective solutions to problems. Leithwood found that transformational leadership practices significantly influenced teacher collaboration. He also determined that significant relationships were present between facets of transformational leadership and teachers' self-reports of changes in attitudes toward school improvement and instructional behaviors.

Women as Leaders

Dr. Mack, as a 20th century scientist and educator, learned, lived, created, and taught in a male-dominated field and culture with a paucity of females in formal leadership positions. Over time the number of women in leadership positions has

increased, fostering research and exploration in the leadership literature pertaining to female leadership styles and issues. Literature on white women, in particular, is extensive (Morrison & Glinow, 1990/1995). Rosener (1990/1995) charts the different expectations and paths that men and women faced prior to the 1960s. Women were expected to be supportive of others, cooperative, and understanding in complementary roles: wives, mothers, volunteers, teachers, and nurses. On the flip side, men were expected to exhibit strength, competitiveness, and decisiveness. Career paths for women were generally devoid of lengthy series of formal authority positions and resource control. While the first generation of female executives emulated many of the behaviors and traits that were successful for men in leadership positions, successive generations are relying on the skills and attitudes that grew out of their socialization as women. Their characteristics perceived to be feminine are helping, not hindering, their success. Rosener suggests that women originally compensated for the lack of formal authority and control over resources by using their natural and/or socially permissible behaviors to succeed in getting their work done. Women have found this interactive leadership style to be effective and believe that individuals want to perceive that they are contributing to a higher purpose, learning, and growing- tenets of transformational leadership.

A survey sponsored by the International Women's Forum, *The IWF Survey of Men and Women Leaders*, revealed both similarities and differences among men and women. Rosener (1990/1995) did not find a wage gap between male and female respondents and did find that both men and women experience conflict between work and family in equal numbers. Male respondents were more likely to self-describe in

ways suggestive of transactional leadership, while female respondents referred to themselves in ways attributable to transformational leadership. Rosener then interviewed a segment of the women respondents who self-reported a transformational style. She calls the style revealed through these interviews interactive leadership because of the work of the leaders to positively engage subordinates. Attributes of interactive leadership include: (a) encouraging participation, (b) sharing power and information, (c) enhancing other individuals' self-worth, and (d) causing others to become excited about their work. Rosener notes that performance takes on new relevance in fast-changing, challenging environments, leading to more flexibility in solutions, structures, and ways of leading. This suggests, as many organizations have found, that the traditional command-and-control style of leadership does not create the type of collaborative problem-solving milieu needed for success in our highly competitive, flattened world (Friedman, 2006). Anderson (1995) shares her belief that we must create opportunities for finding, respecting, and integrating both the masculine and feminine perspectives that each of us possesses. She declares that failure to assimilate the feminine perspective into leadership means ". . . we will continue to suffer a preponderance of transactional leaders in the face of a critical need for transformational interactive leaders, leaders who are authentic- self-disclosing, self-regulating and collaborative" (p. 59).

While research indicates some gender differences, differences within each sex are more pronounced than differences between them (Schein, 1989/1995). Schein highlights a significant conclusion by the Center for Creative Leadership (CCL) researchers that "as individuals, executive women and men seem to be virtually

identical psychologically, intellectually, and emotionally" (p. 164). AT & T Assessment Center Reports also indicated that males and females in managerial positions shared more similarities than differences in abilities and on personality and motivation factors (Morrison & Von Glinow, 1990/1995). In a study of leadership in vocational education, Moss and Jensrud (1995) found that female vocational administrators were judged to be slightly more effective leaders than males in the same positions by both male and female subordinates and/or peers, with women tending to have a greater level of positive leader characteristics. In a study by York (2005), gender roles of the leaders were not found to lead to differences in behaviors for leaders in feminine, masculine, and androgynous groups. York also examined raters' views of female and male leaders, finding no differences in effectiveness ratings of the leaders based on leader gender. In an examination of the relationship between levels of moral reasoning and the use of transformational leadership behaviors exhibited by public school administrators, Daniel (2005) found no significant differences between male and female administrators.

Regardless of gender, effective leaders work to implement their visions, vary their leadership behaviors according to the demands of the situation, and address complex changes (Schein, 1989/1995). In discussing the structural and attitudinal nature of the glass ceiling, Schein stresses the impact of the structure of the work world that is still based upon families having a full-time spouse/parent at home, and suggests that instead of asking women to choose between motherhood and careers, we should be asking how work can be restructured in a society where work and family now interface instead of being separate. Women leaders, she speculates, may

be more likely to understand and grapple with accommodating a work and family interface. In line with the view that women have different career and leadership development experiences than men, CCL (Ruderman, 2004; Ruderman & Ohlott, 2002) undertook a major study of the choices, tradeoffs, and decisions regarding work and life that often challenge female leaders. The research involved 61 women leaders in mid- and senior-level executive positions with major responsibility and a base salary range from $80,000s to greater than $205,000. Five main themes emerged from this research that affect how high-achieving women deal with their careers and lives: (a) authenticity, which is the need for a healthy mesh between one's values and beliefs and one's daily activities and behaviors. This is problematic for some women who work in an organization that demands a specific leadership style; (b) connection, which is in reference to our basic human need to be close to others; (c) agency, a fundamental psychological drive to control one's destiny. Agency was found to be one of the strongest needs of high-achieving women, though historically it has been associated with traditionally masculine qualities; (d) wholeness, referring to the desire to bring together various life roles in a unified whole. This is at odds with organizations founded on the premise that work comes before anything else; and (e) self-clarity, the wish for increased self-understanding that operates as a motivational factor in continuing one's development.

Leadership barriers. Ruderman (2004) identifies several barriers to leadership that interfere with recruitment and retention of women leaders. Barriers include prejudice, differential opportunities, isolation, factors involving people making opportunity decisions based on their own comfort level, and conflict between work

and family in demanding career positions. In looking at the evolution from barriers faced by women to barriers faced by mothers, Belkin (2003) addresses the *opt-out revolution* in an article centered on a women's Atlanta book club. Members are graduates of the once male bastion Princeton, which first admitted women in 1969. Of the ten members, only one- who has no children- works full time. Half of these well-educated women are not working; one works in business with her spouse; one is employed part time; and two are freelancers. In discussing the choices of the women in this group, it is apparent that balancing the needs and philosophical issues of motherhood with high-demand careers requiring lengthy hours on the job and travel are leading to a definition of success that does not equate to power and money. The members of this group have compelling stories. One, an attorney, spent three months working seven days a week, often 15 hours at a clip, while nursing a child, to prepare for a trial. The morning of the case, the judge postponed it and then ended up removing it from his calendar. Why? The judge decided to go fishing for two weeks. A crucial conversation with her husband about her ultimate goal, to become partner, and the outcome of achieving it, which she determined would be financially beneficial but personally detrimental, prompted her to quit. She could not reconcile the roles of parent and attorney without wearing herself thin in pursuit of excellence in both. The data are insightful: During the years from age 25-44, a critical time for developing careers, two thirds of mothers who have not left their positions work part time (less than 40 hours per week). Somewhere between one fourth and one third of professional women are not employed at all. Harvard Business School, in surveying

women from the classes of 1981, 1985, and 1991, determined that only 38% were employed full time.

Hard work versus competition. Tischler (2004) also questions what happened to the women who were supposed to inhabit the corner offices after three decades of the women's movement amid this era of amply qualified female candidates. While covert discrimination and workplaces poorly suited to accommodating women's family responsibilities may be contributing factors, Tischler brings up the possibility that while women may work as hard as men, most don't compete as hard.

Charles A. O'Reilly III of Stanford, in conjunction with doctoral student Olivia O'Neill, found in a study of Berkeley MBAs that corporate success is more a function of how hard individuals decide to compete and less one of gender discrimination. O'Reilly employs a tournament analogy in discussing their findings:

> One way to think about careers in organizations is as a series of tournaments at which employees at lower levels compete with each other for promotion to higher levels. Gaining a promotion- winning a round in the tournament- enables a person to compete in the next round. Over the years, those with less motivation and ability are eliminated, and the remaining participants compete for the top-level positions in the firm. What we see in this study is that those who choose to enter the tournament and put in more effort and sacrifice seem to be traditional males. But others may choose not to play the game, including men and women who want more balance in their lives. . . . (Rigoglioso, 2004)

In exploring that theme, Tischler (2004) discusses Marta Cabrera, who held a high-profile vice president position at JP Morgan Chase in 1999. After an epiphany at

her second-grader's birthday party, where she realized friends and family knew her child better than she did, Cabrera quit in 2000 to take a scaled-back position with another firm. According to Cabrera:

> There's a different quality of what men give up versus what women give up when they attempt to reconcile the demands of a senior job with those of family responsibilities. The sacrifices for women are deeper, and you must weigh them very consciously if you want to continue. I didn't want to be the biggest, best, greatest. I didn't feel compelled to be number one. (Tischler, 2004, p. 3)

The academic workplace. Business organizations are not alone when it comes to issues regarding leadership barriers. Kerber (2005) tackles the academic workplace, addressing the remarks of Lawrence Summers referenced earlier in this study regarding why there are limited numbers of women pursuing careers in math and science. She questions Summers' line of reasoning where it touched upon the notion that women do not want to work the requisite 80-hour weeks needed for an academic career and the value of that many work hours for any individual. In tracing the path from three or four decades ago, when women were barely visible in graduate programs, through the difficult struggles to gain equity, she points out how much has been accomplished in one generation. However, discrimination, overloaded service expectations, and ongoing distrust of women's ability to think, akin to that which surfaced in the late 1940s, seem to be resurfacing. Kerber notes Anne Firor Scott's attempt to draw generalizations regarding the majority of women who lived from colonial times until the middle of the 20th century (a period covered by the first three

volumes of *Notable American Women* that she was reviewing in the mid-1970s). In effect, only one generalization was apparent: Accomplishments bringing recognition for these women occurred following menopause. Kerber states that today's institutions are structured in such a way that this generalization is not obsolete.

The lack of coherent benefit policies and tenure clocks created for a male academic profession, without biological clocks in mind, are barriers to successfully balancing parental and professional roles. Teaching hospitals also face on-going issues with parenting and training conflicts (Breslow, 2007). Combine the fact that women now comprise half of the total number of medical students with the realities of training for some medical specialties extending into students' 40s, along with limitations on leave time and other regulations, and one can readily perceive the incongruence between professional and personal roles and institutional structures.

Leadership in Education

Confluence of role expectations. Today's schools face the challenge to provide value-added for all students in consideration of the demands of our 21st century information-based global economy and organizational requirements for high-performing workers (Ash & Persall, n.d.; Institute for Educational Leadership, 2000; Lashway, 2002). Changing times are driving changing schools, suggesting the need for different types of leadership. Structural elements, some of which derive from our agricultural and industrial revolution heritage, are impediments to achieving the high levels of outcomes that were at one time expectations for small numbers of students. Those who work in schools face a daunting challenge in meeting daily demands, let alone transforming the heart and soul of the educational system. Members of the

Institute for Educational Leadership (IEL) Task Force, while having a diversity of opinions on many topics, largely agreed on two issues: (a) leadership for learning is the top priority of the principalship; and (b) the current formulation of the principalship as a middle management position overloaded with basic building operational responsibilities does not fulfill this fundamental priority (2000). The role of principalship has shifted from the 1980s definition of instructional leadership, with a task-oriented, top-down focus on curriculum and instruction, to a current view of instructional leadership that is democratic, community oriented, with a shared vision grounded in agreed-upon standards for student learning, and accountability for the outcomes (Lashway, 2002). This perspective of the role does not abrogate the existing managerial responsibilities of the role, including budgets, building operations, and bus issues, a set-up for failure in meeting the challenges of the 21st century.

The sense of the overwhelming nature of the challenges surfaced in Martin's study (2007). Martin formulated an educator leader profile derived from his study of everyday leadership. His participants were challenged by the daily press and interactions with students, parents, and other stakeholders. Issues of time, resources, student motivation, and relationships, along with the multiplicity of tasks to be undertaken in a day, created the impression that these everyday educational leaders were overwhelmed by the tasks and the importance of their role. Respondents viewed becoming a leader as a journey, rather than as an event. In identifying their own impact as educational leaders, they focused on developing others, revealing their passion for their work.

Defining school leadership. In an attempt to define and understand school leadership, Leithwood and Duke examined the articles on educational leadership that appeared in four major administration journals during the period from 1985 to 1995 (Lashway, 2002). They identified six discrete types of leadership: (a) instructional leadership, influencing teachers' work to improve student achievement; (b) transformational leadership, growing the capacity and commitments of staff; (c) moral leadership, grounded in the leader's values and ethics, influencing by connection to ideas of right and wrong; (d) participative leadership, involving other stakeholders in decision making; (e) managerial leadership, addressing leader functions, tasks, and behaviors with a focus on effectiveness and efficiency; and (f) contingent leadership, adaptation of behavior to fit the context. Leithwood and Duke suggest that a greater understanding of these six themes is preferable to redefinitions of leadership.

Given the complex nature of leadership, with its multiplicity of manifestations and variations, a formal definition of school leadership with excessive constraints might be less preferable than a seemingly appropriate broad working notion of leadership (Leithwood & Riehl, 2003). Leithwood and Riehl provide a succinct leadership definition that derives from the dual functions of providing direction and exercising influence: "It may be said that leaders mobilize and work with others to articulate and achieve shared intentions" (p. 7). The authors discuss various assumptions and conceptions embedded in this definition: (a) leadership is social; (b) leadership incorporates goals and direction; (c) leadership is a process of influence; (d) leadership is a function; and (e) leadership is situational (contextual and

contingent). Leithwood and Riehl also offer six claims pertaining to school leadership that are supported by research literature, including the vital claim that successful school leadership is a significant contributor to improving student learning. Principals and teachers are the primary sources of this successful leadership, which is and should be distributed to others. The authors establish the claim that a core set of basic leadership practices is of value in the majority of situations: setting directions by identifying and articulating a vision, promoting acceptance of group goals, and creating high performance expectations; developing people through providing intellectual stimulation, individualized support, and appropriate modeling; and redesigning the organization through strengthening its culture, revamping its organizational structures, and creating collaborative processes. Leithwood and Riehl examine the claim that successful leaders need to act in accordance with accountability-oriented policy contexts and also address the need for successful leaders to promote school quality, equity, and social justice through the practices they enact. These claims are mirrored in the Interstate School Leaders Licensure Consortium (ISLLC) standards discussed below.

Varied and changing models and perspectives. The IEL (2000) Task Force emphasized the need for new leadership models, indicating that while the principal is responsible for providing the leadership needed for student learning, a restructuring of roles could distribute responsibilities for accomplishing the necessary work. The IEL Task Force referred to the mixed results in improved student learning that have been found in shared leadership models such as school councils and site-based management implementations. Though there is no specific model of distributed

leadership that will be effective for every school, distributed leadership to support instructional transformation and the use of technology to facilitate managerial and paperwork tasks are promising practices that offer the potential to support balancing the dual roles of building manager and instructional leader (Barbacane, 2007). Ash and Persall's (n.d.) Formative Leadership Theory, grounded in the belief that educators are responsible for both student and adult learning within the school setting, reflects distributed leadership components. Their theory incorporates ten principles in support of quality leadership. These principles focus on team learning, collaborative problem solving, teacher leadership, trust, encouragement of innovation and creativity, and a focus on people and processes rather than paperwork and less valuable administrative tasks. DuFour (2003), in a discussion of the superintendent's role in building a professional learning community, touches upon many of these principles in illustrating how a superintendent should and can be both tight on purpose and big ideas and also encourage individual and organizational autonomy in daily operations that is guided by parameters with focus and direction. His exemplary superintendent exhibited tightness by a focus on learning and implementation of collaborative teams to support a collective effort.

Goldberg (2001) has interviewed 43 diverse educational leaders for *Phi Delta Kappan* and *Educational Leadership* since 1989. In reviewing these interviews, he concluded that though leadership varies in form and possesses multiple characteristics, there are five qualities readily apparent. Each of the eminent, influential leaders he interviewed evidenced (a) a *bedrock belief* in the potency and utility of their undertakings; (b) *courage to swim upstream* for the sake of their beliefs

regardless of the barriers; (c) a *social conscience*, especially regarding racism and poverty; (d) a *seriousness of purpose*, with high standards and lengthy service to their causes; and (e) *situational mastery*, congruence of personal skills with the work to be accomplished. Goldberg suggests that situational mastery is the particular factor impeding the identification of a generic set of characteristics defining what is needed to be an educational leader. Jobs, skill sets of leaders, contexts, and cultures are not identical. Congruence between the leader and the necessary work is critical. Goldberg does not believe that his interviewees could have swapped positions and achieved the same successful outcomes.

Role development and expectation standards. Concern exists regarding the lack of qualified candidates for principalships (IEL, 2000; Lashway, 2002). Principals are more and more finding that the job is unrealistic and retirements are occurring at ever earlier ages. Impediments to attracting qualified candidates include compensation that is incongruent with job responsibilities, high levels of job stress, unreasonable time requirements, the challenge of satisfying stakeholders such as parents and community members, and social problems that impede the focus on instructional issues. The IEL Task Force recommends “filling the pipeline” with effective school leaders by addressing issues with recruitment, traditional principal preparation programs, retirement portability restrictions, inconsistent standards, and race and gender gaps that are narrowing but still in existence. Rigor in licensure standards is presented as necessary to significantly improve principal preparation. The IEL Task Force notes that The Interstate School Leaders Licensure Consortium (ISLLC) standards are the single-most influential effort to improve schools by

strengthening leadership. The Council of Chief State School Officers (CCSSO) has adopted six ISLLC Standards for School Leaders:

> A school administrator is an educational leader who promotes the success of all students by (1) facilitating the development, articulation, implementation, and stewardship of a vision of learning that is shared and supported by the school community; (2) advocating, nurturing, and sustaining a school culture and instructional program conducive to student learning and staff professional growth; (3) ensuring management of the organization, operations, and resources for a safe, efficient, and effective learning environment; (4) collaborating with families and community members, responding to diverse community interests and needs, and mobilizing community resources; (5) acting with integrity, fairness, and in an ethical manner; and (6) understanding, responding to, and influencing the larger political, social, economic, legal, and cultural context. (CCSSO, 1996, pp. 12, 14, 16, 18, 20, 22)

In reinventing the principalship, filling the pipeline with effective school leaders is one of three challenges addressed by the IEL Task Force. The Task Force recommends supporting the profession by focusing on student learning in preparation, professional development and improved sustained training, increasing pay, and fostering shared goals and efforts among organizations. The focus should be on guaranteeing quality and results, with more effective and frequent evaluation of principals and equitable methods for holding principals accountable for student learning, in addition to the creation of more effective and robust systems for gathering data essential to informing principal leadership.

Technological advances, accelerating ever faster as we begin the 21st century, have also provided both challenges and standards for school administrators. Technology literacy is playing a critical role for both schools and their leaders (Johnson, 2005). In 2002 the International Society for Technology in Education (ISTE) adopted the Technology Standards for School Administrators (TSSA). Johnson points out that these have become the de facto national standards for educational leaders, who are expected to:

(1) inspire a shared vision for comprehensive integration of technology and foster an environment and culture conducive to the realization of that vision;

(2) ensure that curricular design, instructional strategies, and learning environments integrate appropriate technologies to maximize learning and teaching;

(3) apply technology to enhance their professional practice and to increase their own productivity and that of others;

(4) ensure the integration of technology to support productive systems for learning and administration;

(5) use technology to plan and implement comprehensive systems of effective assessment and evaluation; and

(6) understand the social, legal, and ethical issues related to technology and model responsible decision making related to these issues. (ISTE, 2002, pp. 1-2)

Leadership in Science, Technology, Engineering, and Mathematics (STEM)

Science, policy, and the public. One can intuit from reading an Op-Ed piece released by the St. Louis Post-Dispatch ("Science editors," 2007) that leadership in STEM fields is challenged by issues not only regarding recruitment and retention, but also in the realm of politics and ethics. Dr. Julie Gerberding, Director of the U.S. Centers for Disease Control and Prevention, was scheduled to appear before a Senate committee to testify on the public health implications of global warming. As a matter of routine, she submitted her remarks to the Office of Management and Budget (OMB), as well as to public health groups. OMB staff, political appointees, performed surgery on the text, removing references to CDC belief that climate change is a serious public health concern. According to the White House press secretary, Dana Perino, the text was deleted because officials believed it was incongruent with the scientific conclusions in a report by the Intergovernmental Panel on Climate Change (IPCC), which shares the 2007 Nobel Peace Prize with Al Gore. An underlying assumption of this and similar acts suggests that White House political appointees are more knowledgeable about the science in the IPCC reports than Dr. Gerberding and her staff. In referencing other instances of changes to scientific documents, this opinion piece makes the case that aligning documents with administration policy is not the same as aligning them with reality. While our increasingly competitive global environment is fermenting unease regarding our relative position among other countries and our future prosperity, leadership has ramifications that extend beyond a parochial, nation-state perspective.

Dr. Shirley Ann Jackson, President of Rensselaer Polytechnic Institute, discussed the need for science and leadership to coalesce in new ways, beginning her Gustav Pollack Lecture at Harvard University in reference to that same issue of global warming and the IPCC conclusions that the Op-Ed piece points out have been ignored, downplayed, and denied by the Bush administration:

> When the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report on February 2nd in Paris, calling global warming "unequivocal," it became an entry point to understanding that- as a planet, as nations, as individuals- we must find the leadership to make change, and to do that we must find the leadership to trust science. (Jackson, 2007, p. 1)

In discussing the exponential changes of the last century, Jackson addresses the proliferation of knowledge and self-proclaimed experts that reduces the value of both information and science and challenges the authoritative role of science in facilitating the formation of sound public policy. Citizens and politicians alike do not know which expert to believe. Jackson calls for consistent investment in human intellectual talent and strong leadership to create sound, progressive public policy. Leadership is essential to address innovations necessary to ensure national and global security, as well as to promote a cultural change to value science and scientists. Jackson issues a reminder that leadership extends to all of us within our particular spheres of influence.

Collaborative endeavors in the face of urgency. Economic prosperity and global technological leadership in the United States have for the most part been driven by our science and engineering workforce, with a shrinking sector of the

population supplying the needed technical abilities (Building Engineering & Science Talent, 2004). An aging science and engineering workforce (half are 40 and older), combined with the need for scientists and engineers in specific technology sectors, and global competition in generating science and engineering talent are looming challenges creating a sense of urgency. One ramification from this sense of urgency is the formation of collaborative alliances with action agendas.

The Business-Higher Education Forum (BHEF), in the belief that America's prosperity depends on a world-class workforce, especially in STEM fields, has initiated a nationwide effort to double the number of STEM graduates by the year 2015, enhance America's future workforce quality, and bolster our research and development infrastructure (2006). The BHEF report creates a sense of urgency through highlighting metrics of declining educational attainment and research productivity in the U.S., including college degrees granted in STEM fields, authorship of scientific journal articles, patents, and Nobel prizes. Of particular note is the claim that American students appear to be mostly uninterested and unprepared to assume leadership in STEM careers. BHEF's initiative targets six critical areas: (a) science and mathematics culture and achievement, with a goal to increase student awareness, interest, and achievement; (b) STEM pipeline, focused on attracting and graduating increased numbers of students in STEM disciplines, especially women and minorities; (c) institutional and systemic reform, focusing on learning methods and systemic reforms in support of greater student achievement in STEM disciplines; (d) teaching workforce, promoting new ways of recruiting, training, supporting, and collaborating with K-12 educators who are proficient in science and mathematics;

(e) STEM policy, with the goal to advance policy and programs enabling higher education, private industry, and government agencies in the U.S. to be competitive in the global hunt for the greatest STEM talent; and (f) advocacy and action, with the purpose to stimulate national dialogue and local initiatives through forming alliances and collaborative endeavors among business, education, and government.

Building Engineering & Science Talent (BEST) is a public-private partnership with the express goal of strengthening and diversifying the American workforce in science, engineering, and technology through growing the participation of underrepresented groups- women, African Americans, Hispanics, Native Americans, and individuals with disabilities (2004). In examining the journey from the pre-K-12 educational system in the United States, which is charged with building the necessary foundational skills for all citizens, to the workplace with its increasing knowledge demands, BEST identifies colleges and universities as the strategic bridge in supplying world-class talent through the development of a changing talent pool. Research universities, in particular, carry a leadership burden as the pinnacle of our graduate education system. BEST worked to construct a foundation for action by conducting a net assessment of best practices in pre-K-12, higher education, and the workplace, utilizing three blue-ribbon panels in a parallel operation to identify and evaluate programs that were designed to increase representations of underrepresented populations. In this endeavor, they began with determining an analytical method, constructing a national sample of programs, applying the specified analytical criteria in rating programs, and then drawing inferences from exemplary programs to formulate a set of design principles serving as indicators of what is needed to be

successful. BEST's eight design principles (p. 5), culled from exemplars and promising programs, combine to play an essential role in successful outcomes in transitioning from school to work:

1. Institutional leadership, evidenced by a commitment to inclusiveness throughout the campus community;
2. Targeted recruitment, evidenced by investing in and implementing a K-12 feeder system;
3. Engaged faculty, evidenced by developing student talent as a rewarded faculty outcome;
4. Personal attention, evidenced by attending to the learning needs of every student through mentoring and tutoring;
5. Peer support, evidenced by opportunities for student interaction that build support across cohorts and allegiance to the institution, the discipline, and the profession;
6. Enriched research experience, evidenced by hands-on opportunities beyond the classroom and summer internships connected to the work world;
7. Bridging to the next level, evidenced by institutional relationships that assist students and faculty to foresee pathways to milestones and career development; and
8. Continuous evaluation, evidenced by ongoing monitoring of process and outcomes that guide program adjustments to heighten impact.

BEST refers to the challenges of identifying what is effective, adaptable, affordable, and worthy, cautioning that their findings are a beginning, not a final determination. The organization also notes that a greater number of institutions will need to prioritize and commit to diversity in science, engineering, and technology. BEST believes that higher education will need to reframe the issue from one of competitive advantage to one of building capacity.

Progress and continuing challenges. Both encouraging developments and significant challenges in preparing underrepresented minority undergraduate scholars for doctoral education in STEM fields were identified by the Leadership Alliance Presidential Forum (2005) panel. The panel found that an increasing number of minority students are attending college, some of whom are interested in science and engineering. Public and private grant support for STEM education has increased. In addition, there is an increasing understanding of the need to grow our domestic pool of undergraduate and graduate students in STEM fields. The panel also noted the growing attention being paid to best practices involving minority students in science and engineering and the increasing body of research literature revealing both successes and challenges. A variety of institutions have greater numbers of faculty who have been successful in engaging students in STEM fields and research opportunities for minority students in STEM fields have expanded. In an ironic twist, an unintentional consequence of Lawrence Summers' Harvard controversy regarding the role of women in science, discussed earlier in this study, surfaced in the findings of this panel as heightening the attention being focused on diversity in science.

The forum panel found several ongoing challenges, including the lack of rigor in K-12 science and mathematics education, particularly in schools with the highest populations of minority students. Gateway courses designed to weed out first-year science and engineering students still persist. Leadership training for administrators and faculty is needed to guarantee prioritizing campus initiatives that focus on minorities in science. Faculty and students need to be aware of the level of rigor of undergraduate preparation and how this relates to the expectations of graduate programs. The panel also highlighted the need to address personal issues faced by minority students, including those involving self-concept, motivation, study habits, family, and finances. Findings from a workshop on support of graduate students and postdoctoral researchers in science and engineering, sponsored by the National Science Foundation (NSF), Council of Graduate Schools (CGS), and National Institutes of Health (NIH), revealed the financial implications of spending one fourth of a career (10 years out of 40) in training and the effect on lifetime research achievements (Barnhill, 2004). The combination of poor pay for graduate students and postdocs and the lengthy and uncertain journey to a first professional position are potential barriers to attracting and retaining STEM students. The co-chairs of the workshop, Barnhill and Stanzione, concluded that there is a national disconnect between a desire to reap research benefits from a cheap, young labor force (i.e. graduate students and postdocs) and the critical issue of making STEM careers attractive to young individuals.

The University of Maryland, Baltimore County (UMBC), has been recognized for success in producing minority scientists and engineers, utilizing a “university as

mentor" approach which embeds focused, ongoing support of women scientists at all student and faculty levels (Hrabowski III, 2007). Leadership has been modeled from the top- when applying for a NSF ADVANCE grant, Hrabowski, UMBC's president, took the role as Principal Investigator (PI) in order to communicate the importance of the initiative throughout the campus, and also to reinforce the importance of men increasing their knowledge of the challenges confronting women scientists and engineers. The need for UMBC's efforts can be drawn from a 2005 study indicating the underrepresentation of women faculty at all levels in the top 50 research universities, particularly as full professors, with minority women less likely to attain tenure or full professor rank than Caucasian women or men regardless of race. UMBC's ADVANCE Program framework is a comprehensive, threefold approach derived from what has been learned in producing minority scientists that focuses on: (a) policy, practices, and resources in support of recruitment, hiring, and advancement of women at all ranks; (b) campus-wide engagement in formal and informal dialogue on issues of diversity in STEM fields; and (c) targeted mentoring programs in order to establish a clear and comprehensible pathway for STEM women to achieve tenure and promotion and to assume university academic leadership positions. The outcomes are notable. Since the program's initiation, the number of female tenure-track faculty grew 48%, from 29 in the fall of 2003 to 43 in the fall of 2007, as contrasted with a 4% increase in male tenure-track faculty during the same period, from 137 to 142. Hrabowski believes that what the university has learned about institutional transformation, including culture change, a need for mentoring, and building a strong

sense of community, created the conditions that allowed them to have the crucial conversations needed to address the challenges of underrepresentation in STEM.

Perspective of the Field: Metrics of Success

Scholarship

It is beneficial to preface an examination of scholarship with a thought to why a scholarship of teaching and learning is important and necessary. Shulman (2000) offers three reasons for investing in such scholarship. The first and most important reason to engage in the scholarship of teaching is professionalism- professional role and responsibility. Shulman reminds us that each participant in higher education belongs to two professions, his or her discipline and his or her profession as an educator. Responsibilities of scholars are shouldered in these intersecting domains- including those to discover, to connect, to apply, and to teach. The second rationale provided by Shulman is pragmatism. Pragmatism involves the requisite endeavors that continually improve one's work as an educator and meet objectives and responsibilities to students. The third rationale is policy. This would include the capacity to effectively respond to valid questions from legislatures, boards, and demands of the emerging market for higher education. Shulman draws a distinction between equally important activities: scholarly teaching (grounded in field-appropriate resources, strategies, methods and values) and a scholarship of teaching (when the educator's work becomes public, peer-reviewed, and exchanged).

In examining what it means to be a scholar, Boyer (1990) refers to a prevailing view that to be a scholar, one needs to be a researcher, with publication as the primary metric to measure scholarly productivity. Data from the 1989 National

Survey of Faculty included by Boyer confirm this view. The survey asked faculty of postsecondary institutions how important different criteria were to the granting of tenure in their particular departments. When it came to the number of publications, 56% of faculty at research institutions and 55% of faculty at doctorate-granting institutions rated this criterion as very important. These were the highest percentages of any category. Other criteria in the survey included recommendations from outside scholars, research grants received by the scholar, and the reputations of presses or journals publishing the books or articles. Student evaluations of courses taught were perceived as comparatively less important: 10% of faculty from research institutions and 19% from doctorate-granting institutions perceived this to be very important for granting tenure. Service within the scholar's discipline (6% and 8% respectively) and service within the university community (3% and 6% respectively) were not perceived as very important in the granting of tenure. Boyer suggested broadening the definition of scholarly work to perceive scholarship as encompassing discovery, integration of knowledge, teaching, and service. Smith and Their (n.d.) of Jefferson Medical College indicate that expanding the definition of scholarship holds promise for attracting and rewarding faculty who have diverse interests, backgrounds, and skills. Jefferson Medical College is an active proponent of the move to redefine faculty roles and restructure reward systems to promote scholarship. Commonly, however, in spite of considerable involvement of the nation's academic leaders and faculty, problems identified in the 1990s remain today (Diamond, 2006). Promotion and tenure decisions are still primarily based on research and publication and much less importance is placed on teaching and community service endeavors.

What gets measured? Dr. Christopher Palma, Penn State University Outreach Fellow, prefaced his answer to the question of how the field (scientific and postsecondary communities) perceives success with the fact that though it is difficult to generalize, *publish or perish* is alive and well, though endlessly debated (personal communication, November 19, 2007). Dr. Palma notes that the Eberly College of Science Astronomy & Astrophysics webpage states, "One measure of the impact and level of our activities is indicated by Penn State ranking fifth in space science citations per paper over the previous five-year period, as reported recently by *Thomson Scientific ISI*." Two of Penn State's astronomers, Professors Eric Feigelson and Donald Schneider, have received recognition for their contributions to space science based on the number of times their research was cited in papers published during the time period between 1981 and 1999. At the time of his communication, Dr. Palma's work was cited 403 times, with his most highly cited paper being his thesis, with 53 citations. He contrasted that with Dr. Schneider's most highly cited paper, which has more than 1400 citations.

Thomson Scientific's *Essential Science Indicators* (2007) is a compilation of statistical information that is based on 10 years of data. Publication, citation, and cites-per-paper counts for scientists, institutions, countries, and journals are available on the web to subscribers. The magnitude of the data collected is immense: during a recent 10-year period about 9 million articles, notes, and reviews from ~9,000 indexed journals were recorded. In the two-decade period from 1983-2002, the scientist with the most citations to his published research was Dr. Bert Vogelstein from Johns Hopkins University, at more than 100,000 citations (Thomson Scientific,

2003). The most frequently cited paper during this time period was a report by Chomczynski and Sacchi on a method of isolating RNA, with 49,562 citations. In a look at the category of molecular biology and genetics (Thompson, 2007, January), from January 1, 1996-October 31, 2006, scientist E. Lander topped the list with 117 papers and 27,411 citations. Harvard University was at the top of the institution list in this field with 7,866 papers and 421,360 citations. The United States far outpaced its nearest counterpart, with 117,269 papers and 3,905,292 citations. England was second with 22,732 papers and 716,821 citations. The journal *Cell* had the most citations, at 588,211. Turning to space science (Thomson, 2005), one can find a ranking of high-impact U.S. universities from the period 1999-2003: Princeton University tops the list at 842 papers and an average 16.83 citations per paper; Pennsylvania State University is ranked fifth with 609 papers and an average 14.35 citations per paper.

In another take on measuring scholarly accomplishments, a for-profit company partly owned by the State University of New York at Stony Brook compiles a ranking of graduate programs at research universities based on what is supposedly the first objective measurement of per-capita scholarly accomplishment (Wasley, 2007a). The index algorithm incorporates the number of professors in a specific program, the number of books and journal articles they have written, how many times other scholars have cited them, and their awards, honors, and grant dollars. The algorithm produces a number reflecting the average productivity of department faculty. Princeton University recorded the highest faculty scholarly productivity index in mathematics for 2007 at 2.01. Many universities are holding off on embracing this

data until they can compare it with data released by the National Research Council. In the variations of metrics, interpreting scholarship through a publication lens with quantity measures appears to be well-entrenched.

Alternative criteria. Boyer's 1990 proposition to move away from the teaching versus research debate by rethinking scholarship as not only original research, but also synthesizing and reintegration of knowledge, professional practice, and the transformation of knowledge through teaching, was utilized, modified, or avoided by various disciplines (Diamond, 2006). Braxton, Luckey, and Helland (2002) also note that Boyer's proposition portrays how scholarship should be performed, not how it is in reality, leaving the question of the actual levels of engagement that may or may not exist in each of Boyer's four domains. While Boyer's work was catalytic in placing the issues of faculty rewards and scholarship on many institutional agendas, Diamond states that using a categorical approach to scholarship (i.e. Boyer's four-part structure) as opposed to focusing on the quality of scholarly work creates problems in implementing change across disciplines. He highlights a broadly overlooked finding from work with the varying disciplines: "Although faculty from different disciplines cannot agree on terminology, in large measure, they do agree, on those characteristics that combine to make an activity scholarly" (p. 2). Focusing on quality, significance, and process removes the question of where the scholarship occurs and the nature of the work. Diamond indicates a number of advantages to this approach, including clarity and consistency of criteria across disciplines, fairness of the system, ease of implementation, cost-effectiveness,

and promotion of moving away from associating scholarship with the quantity of publications.

Diamond (2006) provides a framework that combines process and product to describe scholarly work of faculty. The following criteria must be met for an activity to be considered scholarly:

1. A high level of discipline-related expertise must be required by the work or activity.
2. The work or activity must be undertaken in a scholarly manner in conjunction with clear goals, adequate preparation, and appropriate methodology.
3. Appropriate documentation and dissemination of the work or activity and its results must occur. A reflective aspect that speaks to the significance of the work, the methodology followed, and the outcomes must be included.
4. The work or activity needs to have significance beyond the individual context, breaking new ground and able to be replicated or elaborated.
5. The process and product or results of the work or activity need to be examined and judged as meritorious and significant by a panel of the candidate's peers. (p. 3)

Evaluating the scholarly contributions of faculty members is not as easy as it might seem (Weiser, 1996). Weiser points out that equating scholarship with research and publication is frequently an overly simplistic methodology, with scholarship undefined and poorly understood at many universities. He also notes that emphasizing

individual achievement in faculty performance can devalue faculty contributions to team endeavors. Weiser considers Boyer's four-part scholarship proposition as effectively encompassing practically every important faculty activity as a form of scholarship. He discusses the definition of scholarship developed and adopted by Oregon State University (OSU), which takes into account that there are essential and important activities performed by universities and faculty that are not scholarship. Weiser sums up the OSU perspective on the nature of scholarship: "Scholarship is creative intellectual work that is validated by peers and communicated. Forms of scholarship include discovery, development, integration, and artistry" (p. 6). Scholarship can be communicated through publications, presentations, exhibits, performances, and a variety of other methods. Validation criteria include accuracy, replicability, originality, scope, significance, influence, and benefit.

Policy reforms to promote multiple forms of scholarship have been found to yield positive outcomes. A national study of Chief Academic Officers of 4-year institutions examined the effect of policy efforts to advance multiple forms of scholarship in faculty roles and rewards (O'Meara, 2005). Campuses that initiated these types of reforms were significantly more likely than those who didn't to report a greater emphasis on teaching scholarship and engagement in faculty evaluation, the use of a broader set of criteria to evaluate scholarship, and greater percentages of tenure and promotion cases emphasizing work in these areas. The Chief Academic Officers of the campuses initiating reform indicated there was a greater congruence between priorities of the faculty and the institution's mission and increased improvement in attention given to undergraduate learning during the past decade.

Quality of Teaching and Student Outcomes

Attempts to broaden the conception of scholarship in higher education over the last two decades have received the greatest amount of attention in the efforts to improve the quality of teaching (Rice, 2006). CASTL, the Carnegie Academy for the Scholarship of Teaching and Learning, set forth in 1998 to promote the development of a scholarship of teaching and learning that first and foremost fosters significant, long-lasting learning for all students (Hutchings, Babb, & Bjork, 2002). In discussing the selectivity of their annotated bibliography, Hutchings, Babb, and Bjork make the primary intent crystal clear:

> We want to be explicit about our primary interest in questions about student learning, about what it takes to foster significant lasting forms of student learning, about what that learning looks like, and about the forms of evidence and documentation that will allow the various disciplines, interdisciplines and professional fields that constitute higher education to foster such learning more effectively. (p. 2)

Rice (2006) notes that identifying best practices in university teaching has been difficult, with Chickering and Gamson's work still the most popular resource on the topic. Chickering and Gamson (1987) offer seven principles of good practice in undergraduate education, derived from 50 years of research, to be used as guidelines to improve teaching and learning. Good practice in undergraduate education:

1. encourages contact between students and faculty,
2. develops reciprocity and cooperation among students,
3. encourages active learning,

4. gives prompt feedback,
5. emphasizes time on task,
6. communicates high expectations, and
7. respects diverse talents and ways of learning. (p. 1)

The Council for Advancement and Support of Education and the Carnegie Foundation for the Advancement of Teaching honored four professors, teaching in the disciplines of mathematics, science, and engineering, as *Professors of the Year* (Wasley, 2007b). The professors have varied techniques, but are in agreement on the fundamentals of successful teaching. Successful teaching requires that educators make their discipline relevant to their students. It also requires giving students the passion and skills needed to assume responsibility for their own learning.

New challenges ahead. In addition to CASTL, the American Association for Higher Education, the International Association for the Scholarship of Teaching and Learning, and the NSF-funded Center for the Integration of Research, Teaching, and Learning are addressing the quality of teaching and student learning agenda. According to Rice (2006), our additive approach to improving teaching is fostering widespread concern that we are creating an academic career that is not viable and will impede attracting the best candidates into the teaching profession. While gains have been made in attending to the importance of student learning, Rice notes that the emerging challenge will be to reconsider both the structure of the teaching role and the delivery of instruction. An additional challenge is emerging from evolving technologies that benefit and challenge the processes of research, review, publication, and tenure (New Media Consortium, 2007). Academic research and scholarly activity

have benefited from the proliferation of access to research materials and abilities to collaborate over time and distance. On the other hand, the combined open-access content models and abundance of audience-generated content is shifting the way we think about scholarship and publication and how these activities are conducted.

Good work in changing times. The increasingly accelerating change of the 21st century brings a coalescence of issues involving collaborative relationships, metrics of excellence, and ethics. Sawyer (2007) contends that his research and experience reveal that the secret to breakthrough creativity is collaboration, defined by Moran and John-Steiner (2004) as involving "an intricate blending of skills, temperaments, effort, and sometimes personalities to realize a shared vision of something new and useful" (p. 11). With Sawyer's and Moran/John-Steiner's perceptions in mind, it is no wonder that the crossing of paths in 1994-1995 of three diverse leaders in their fields led to a productive and creative study (Gardner, Csikszentmihalyi, & Damon, 2001). Gardner's theories and work were examined earlier in this chapter. A cognitive psychologist, he is well-known for his theory of multiple intelligences and studies of creators and leaders. Csikszentmihalyi, whose work was also referenced earlier in Chapter II, is a social psychologist who authors from the evolutionary and motivational perspective. He is recognized for his work in discovering the psychological condition of flow, described as a state in which a person's skills and challenges merge in absorbing ways. Social and moral issues are the realm of interest for Damon, who is a developmental psychologist.

When these leaders in their fields crossed paths, conversations ensued, leading to an examination of questions centering on excellence and ethics. The researchers'

collective backgrounds in creativity, leadership, and moral excellence spurred them to investigate individuals who were successful in melding expertise with moral distinction. Their Project on Good Work focused on the meaning of carrying out good work- defined by the researchers as work that combines the attributes of excellent quality with social responsibility- during a time of constant change. The researchers highlight the challenges of conducting good work that confront professionals in their daily practice, including emerging technologies not fully understood, ethical dilemmas, the loss of hero role models, and concern for a future shadowed in uncertainty.

As part of their investigation of good work, Gardner, Csikszentmihalyi, and Damon (2001, p. 260) investigated eight general areas: (a) goals and purposes; (b) beliefs and values; (c) work process- areas of pride and personal qualities; (d) positive and negative pressures in the area of work; (e) formative influences- childhood, training; (f) perspectives on work- training of next generation, areas of like or dislike; (g) community and family; and (h) ethical standards. The probing of good work is relevant to both aspects of this instrumental case study, first as an interpretive lens to consider the work in Dr. Mack's milieu, and secondly in view of the instrumental nature of this case and implications for leadership in highly challenging and stressful times. An examination of the *Good Work* methodologies, as suggested by Gardner (personal communication, November 5, 2007), will be revisited in Chapter III of this study as they inform the methodologies particularly suited to this study.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Introduction

The purpose of this study is to examine the particular case of an individual who was both scientist and educator in order to inform secondary and tertiary educational leadership in science, technology, engineering, and mathematics (STEM) fields. Given that the study of this case informs the general issue of leadership in educating and retaining individuals in STEM fields, it is an instrumental rather than intrinsic case study (Stake, 1995). Stake reminds us that the researcher striving to portray the complexity of an individual and her life must be cognizant of the reality that lives play out against changing times, reflect patterns and phases, and display both distinctness and commonalities with other individuals and their lives.

Halpern's psychobiosocial model, examined in Chapter II of this study, provides a theoretical foundation for exploring, understanding, and portraying an individual's complex life story. This researcher is striving to portray such a complexity in the study of Dr. Pauline Beery Mack, beginning with the intent to provide a thick description of the contributory factors leading to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science. This thick description seeks to portray the transforming moments that Dr. Mack experienced. Deep exploration and rich narrative provides a window into educational, career, and life challenges that Dr. Mack experienced pertaining to stereotyping, gender, bias, and other issues revealed by this study. This study also looked for ways in which Dr. Mack addressed such challenges and how these challenges impacted her decisions. Of particular interest was the presence or

absence of mediating factors that might have supported successful handling of any identified challenges. Additionally, this study explored how the field perceived and recognized Dr. Mack and whether retrospective evidence corroborated or refuted the perceptions of her time. The data collected for this study regarding the traits and behaviors exhibited by Dr. Mack were analyzed for patterns and connections to the theoretical frameworks of constructivism, creativity, and leadership, examined in Chapter II of this study. Finally, the instrumental purpose of this study is addressed as the findings of this study were examined for implications for secondary and tertiary STEM educational leadership.

Selection of Methodology

Rationale for Qualitative Selection

Once the willingness of the researcher to conduct a qualitative inquiry has been established, there are other issues to examine in determining whether there is a solid rationale for selecting a qualitative methodology. Creswell (1998, pp. 17-18) delineates eight reasons supporting the choice of qualitative research: (1) the nature of the research question(s); (2) the need for exploration of the topic, given that variables are not readily identifiable; (3) the need to provide a detailed view of the topic; (4) the opportunity to study individuals in their natural environment; (5) an interest in writing in a literary style, with the writer bringing herself into the study; (6) availability of adequate time and resources to collect and analyze data; (7) the receptivity of audiences to qualitative research; and (8) to emphasize the researcher's role as an active learner.

The questions driving this study are questions regarding challenges, relationships, events, and processes and, as such, are qualitative questions of how and what. Variables

in this study were not readily apparent and thorough exploration was needed to identify emerging themes and categories. The detailed view of Dr. Mack's life story was essential to support drawing implications for educational leaders, as well as other interested parties. The qualitative methodology provided the opportunity to explore Dr. Mack's life story in the contexts in which she lived, learned, and worked. This researcher has an inherent interest in writing in a literary style, grown larger through her extensive readings of Howard Gardner, Sara Lawrence-Lightfoot, Jessica Hoffman Davis, Virginia Woolf, and many others that helped generate a path to this study. Adequate time and resources were prioritized by the researcher, as the reasons for selecting the qualitative methodology were compelling. The researcher anticipates that audiences will be receptive to this qualitative research study, given the overwhelming challenges of recruitment, education, and retention in STEM fields, the tremendous amount of media and political attention focused on the problem, and the thick, rich story made possible by the qualitative methodology. Indeed, while plumbing the potential available resources at one university, the researcher was informed by the Special Collections Coordinator that she has been waiting for someone to write Dr. Mack's biography, noting that Dr. Mack became a Texas woman with bigger stories than most. The researcher desired to tell Dr. Mack's life story from the perspectives of those who knew her and from detailed analyses of documents, artifacts, and images created by Dr. Mack and a multitude of others. This researcher wanted to emphasize her role as an active learner rather than that of a judgmental expert.

Eclecticism under the Qualitative Umbrella

Biographies, according to King and Chamberlayne (1996), are situated at the cross-roads of the personal and the social. If one utilizes Descartes' epiphany regarding a frame of reference to describe the relationships between points in a plane, allowing one axis to represent the personal and the other the social, the intersection known as the origin is where we would find biographies. The origin is also the intersection in three-dimensional space, an apt descriptor for the intersection of the mutual influences of psychological, social, and biological variables in Halpern's (2006) psychobiosocial model, discussed in Chapter II, which informs this study.

Stake (1995) delineates case study as the "study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (p. xi). This is a study of such particularity and complexity, with the single case being the life story of Dr. Pauline Beery Mack. As Stake indicates, the case is a bounded system, with people clearly meeting the criteria as prospective cases. While there is much about an individual's life story that is and might become of intrinsic interest to the researcher, in this particular case there is a need to understand the processes, challenges, and barriers in secondary and tertiary education related to STEM fields that are crucial to successful navigation of our present and future challenges. Therefore, while intrinsic interests may always be present to some degree when there is a choice of case, the primary use of this case is to understand something other than the case. As such, this study is identified as an instrumental case study.

Statement of the Problem

This study narrows its focus to examine in depth the attributes, behaviors, and experiences of Dr. Pauline Beery Mack in order to address the specific problem of our need to understand the processes, challenges, and barriers in secondary and tertiary education related to STEM fields that are crucial to successful navigation of our present and future challenges.

Research Questions

The research questions for this study were designed with Stake's (1995) caveat in mind that possibly the most difficult aspect that the researcher faces is to craft good research questions that "will direct the looking and the thinking enough and not too much" (p. 15). These questions assisted in structuring the review of documents and interviews. As Stake notes, the issues will ebb and flow during a qualitative research project and this researcher was cognizant of his reminder that we are trying to remain open to the nuances of increasing complexity. Creswell (1998) indicates that one of the compelling reasons to undertake a qualitative study is the nature of the research questions. Is the researcher asking how or what leading to a description of what is taking place as opposed to a why that delves into a comparison of groups? The research questions driving this study are decidedly qualitative in nature:

1. What factors contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science?
2. What patterns or connections to the theoretical frameworks of constructivism, creativity, and leadership are evidenced by the traits and behaviors displayed by Dr. Mack?

3. What transforming moments or epiphanies are evidenced?
4. What, if any, educational, career, and life challenges did Dr. Mack experience that pertained to stereotyping, gender, bias, or other issues revealed by this study?
    a. How did Dr. Mack address identified challenges and in what ways did they influence her decisions?
    b. Were there mediating factors that supported successful handling of challenges?
5. How did the field perceive and recognize Dr. Mack? Is there evidence in retrospect to corroborate or refute the perceptions of her time?
6. What implications do the findings from this research have for secondary and tertiary STEM educational leadership?

The alignment of research questions with interview questions is presented in Appendix B.

Research Design

Introduction

How can we effectively encourage, support, educate, and retain individuals in STEM fields? To address this question, an instrumental case study design was selected to explore in depth the particulars of an individual who was both educator and scientist in order to inform educational leadership in secondary and tertiary STEM disciplines. The specific research questions detailed in the previous section were derived from the literature examined in Chapter II of this study, with the knowledge that these questions

might evolve during the course of this study. The questions were retained as originally formulated.

Constructivist-Interpretive Paradigm

Guba and Lincoln (2005) acknowledge that inquiry methodology cannot be treated as a set of universally applicable rules or abstractions, noting that methodology is inevitably interwoven with and emerging from the nature of specific disciplines and perspectives (pp. 191-192). Qualitative researchers have beliefs that affect how they perceive the world and how they conduct themselves in it. Those beliefs, examined by Denzin and Lincoln (2005), include how the researcher views the nature of reality and being human (ontology), the relationship between the inquirer and the known (epistemology), and how knowledge of the world is attained (methodology). Denzin and Lincoln present four major interpretive paradigms that structure qualitative research-positivist and postpositivist, constructivist-interpretive, critical, and feminist-poststructural. The interpretive paradigm reflecting the researcher's beliefs and undergirding this study is the constructivist-interpretive paradigm. The constructivist-interpretive paradigm is based on the assumptions that there are multiple realities (a relativist ontology), knowledge is co-created by the knower and respondent (subjectivist epistemology), and methodological procedures are naturalistic and, as Guba and Lincoln note, hermeneutical and dialectical. In a constructivistic inquiry paradigm, the researcher seeks understanding and reconstruction, gauges quality by trustworthiness and authenticity rather than by the typical positivist criteria of reliability, validity, and objectivity, and typically presents findings in terms of grounded theory or pattern theories

criteria. The research design for this study reflects the constructivist-interpretive paradigm in its inquiry strategies and data collection methods.

Strategies of Inquiry

The researcher utilizes strategies of inquiry, a collection of skills, assumptions, and practices, to move from paradigm to the empirical world (Denzin & Lincoln, 2005). In this study, the constructivist-interpretive paradigm is engaged, connecting the researcher with case study strategies of interviewing and analysis of artifacts, documents, cultural records, and visual materials. Dr. Mack was born in 1891 and died in 1974. However, former students, colleagues, and others who knew her are still living. The researcher located and interviewed individuals from these various contexts. The researcher identified two significant archive collections pertaining to major segments of Dr. Mack's life and career. One is located at Pennsylvania State University in State College. The other is stored at Texas Woman's University in Denton. The researcher utilized the artifacts, documents, cultural records, and visual materials housed in these collections.

The researcher followed a number of threads as she constructed a portrait of Dr. Mack's life, including Dr. Mack's own publications, documents available through NASA, the archives of the N.Y. Times, and personal visits to places where Dr. Mack lived and worked, concurring with Pinsker on the value in knowing the setting. Pinsker, discussing his research for his 2003 book, *Lincoln's Sanctuary: Abraham Lincoln and the Soldier's Home*, acknowledges the importance of place: "But I had a kind of awakening when I was working on this book- if you don't know the setting, you don't know the people. It really hit home for me" (as cited in Biemiller, 2008, p. A8). It was in viewing

the National Cemetery, located in close proximity to the cottage where Lincoln spent at least one summer season, that Pinsker realized how Lincoln's presence there in the months preceding the Gettysburg Address, while graves became occupied and Lincoln pondered the meaning of war, supported Pinsker's understanding of how Lincoln wrote his speech. The researcher sought to illuminate her understanding of Dr. Mack's life story by developing personal awareness of key relevant settings.

Interpretation and Evaluation

The incredible amount of empirical data obtained in this study necessitated creativity and construction of interpretations (Denzin & Lincoln, 2005). Smith (1994) casts life writing as an empirical exercise that feeds on data such as letters, documents, and interviews. He uses a personal problem-solving strategy that includes having multiple tentative models in his head. In perusing letters for a study of Nora Barlow, he perceived an anomaly which provided a driving research question and led him to the creation of an archive. This researcher, while not anticipating creating the formal archive of the type that Smith stored at Cambridge University, perceived the value in creating a personal archive of the extensive data for this study. She also did not want to miss the joys and frustrations that Smith indicates are inherent in the archival creation process. According to Smith, archival activity provides a major outcome of an overview of the subject's life, beginning the construction of that life. The building of a document archive, organized chronologically, was one step of the biographical aspects of this study. The researcher was cognizant, as Smith notes, that no home study can hold the totality of papers that are important for a life story. The researcher needed to seek out those data pools referred to by Smith that are present in the likeliest and most unlikely places.

Stake (1995) discusses the coding of data that is used for classifying episodes, interviews, or documents to assist in retrieving information at a later date. In coding the data for this study, the researcher was reminded by Stake that searching for meaning is frequently a search for patterns, for consistency, and for correspondence, or consistency within specific parameters. Some potential patterns, derived from the research questions, provided a provisional template for analyzing the data. The researcher expected that patterns would emerge from the analysis, leading to revisions as the life story of Dr. Mack unfolded. The process was iterative as the researcher questioned the significance of the data, reflected, and sought corroboration through triangulation.

Selection of Subject

It is rather obvious, as Smith (1994) reminds us, that the first task in life writing, which was also the first task of this study, is to select a subject. As Smith notes, the subject may or may not be recognized by the general population. According to his thought, the biographer, applied in this study's context to the researcher, needs to think carefully and analytically, to perceive intuitively an anomaly, or to somehow end up being serendipitous, translating to what he terms just plain lucky (p. 289). Smith refers to Edel's reflection: "In a world full of subjects- centuries crowded with notables and dunces- we may indeed ask why a modern biographer fixes his attention on certain faces and turns his back on others" (as cited in Smith, 1994, p. 289). This is a fair question for the researcher to reflect upon and address. Chase (2005) mirrors this issue as she reminds us that all qualitative researchers deal with the issue of a comparatively small sample, sometimes just one individual, that is being studied and a larger whole. As Slavin (2007) suggests, it is important to select a subject carefully in order to obtain valid and

meaningful data. Unlike intrinsic casework that frequently initiates with cases already identified, instrumental casework commonly calls for cases to be selected, with the greatest understanding of our questions relying on a wise selection (Stake, 2005). Sample size, notes Stake, is so small in most case studies that it doesn't justify random selection. In a qualitative study like this one, a purposive sample provides an opportunity for intensive study.

The life story of Dr. Pauline Mack offers both opportunity to learn from a deeply complex life story and to inform current and future educational leadership in secondary and tertiary STEM disciplines. Simultaneous and multiple interests, particular and general, were addressed through the selection of Dr. Mack as the purposive subject for this study. Dr. Mack's life, which played out at another origin located at the intersection of teaching and scientific researching, unfolds in Chapter IV.

Data Collection and Instrumentation

Interviewing

Creswell (1998) offers a view of interviewing as a procedural series of steps (pp. 123-125). The first step is the identification of interviewees based on purposeful sampling procedures. The potential pool of interviewees for this study included Dr. Mack's former students, colleagues, research subjects, and those who may have known her in other contexts. The next step, according to Creswell, is to decide what method of interview is practical and will garner the most useful data to answer the research questions. The researcher was cognizant of Creswell's point regarding the need to interview individuals who are willing to speak their minds and have the ability to articulate their ideas and views. Face-to-face interviews were conducted when possible.

Telephone and email were utilized as necessary, due to distance and/or availability. Creswell recommends using an interview form with open-ended questions with space to write responses to the interviewee's comments. Written notations taken during the interview serve as back-up in lieu of a technical failure with audiotaping and transcription processes. Interviewees were most comfortable with the researcher writing their question responses. Creswell advocates locating an interview place that is free from disruptions. After arrival at the site, prior to interviewing, the consent form for the human relations review board must be completed. Informed consent was obtained from all participants. Creswell rounds out the steps of the interview procedure with advice about adhering to the questions, sticking to the specified time if at all possible, a reminder to be respectful and courteous, and a caution to offer little in the way of questions and advice. He notes that a good interviewer listens rather than talks during the interview. His caveats were followed.

Construction of the Interview Questions

The interview questions for this study were constructed to answer the research questions while being as open-ended as possible in order to avoid missing pertinent information that the researcher might not know to question. The researcher did not want to bias the interviewee by framing questions in a manner that would indicate that a particular response was expected or valued. The construction of the research questions for this study was informed by the interview protocols utilized by Gardner, Csikszentmihalyi, and Damon (2001) and suggested for consideration by Gardner (personal communication, November 5, 2007). Gardner, Csikszentmihalyi, and Damon have been examining how leading professionals in various domains conduct good work.

The authors use the terminology *good work* to convey a perception of work that is both of high quality and socially responsible. Their research involved teams of investigators who conducted extensive one-on-one interviews in domains as diverse as journalism, genetics, higher education, and philanthropy. Information about the interviewees in their research was obtained from various sources prior to the interviews so that interviewers could adapt the protocols as necessary to obtain information that would be of greatest value.

Appendix A contains the interview questions for this study. Appendix B shows the relationship of interview questions to the study's research questions, though the researcher was cognizant of the fact that information would in all likelihood surface at unanticipated points in the interview process, which it did. Not all questions applied to each interview, as the nature of the interviewee's former relationship to Dr. Mack guided the interview process and particular questions asked.

Pilot Study

Rationale

Slavin (2007) discusses the difficulty of developing interview questions that are both rich in the information they provide the researcher and not burdensome to the interviewees. He suggests patterning an interview protocol on existing successful ones, done in this study as informed by Gardner, Csikszentmihalyi, and Damon's (2001) *Good Work* protocols previously discussed in Chapter III. Slavin recommends that the researcher pilot test the preliminary interview questions with several respondents to ensure that each question provides the data the researcher is seeking. There is no exact justification for the sample size in pilot studies, but Simon (2008) suggests that the representativeness of the sample becomes important if the pilot subjects are included in

the total sample and/or the sampling procedure is complex and innovative. Simon also suggests focusing a pilot study on the novel, complex, innovative, or untested elements of the researcher's full study.

Pilot studies are utilized by even the most experienced researchers, as evidenced by the pilot studies conducted by Gardner, Csikszentmihalyi, and Damon (2001) in the fields of medicine and cyberlaw. The pilot test is essentially a trial run of the study, conducted to test the instrument and address any issues prior to the actual study. The researcher then has the opportunity to revise or eliminate items that are confusing or that do not provide the requisite data. There are many additional potential benefits from conducting pilot studies (Simon, 2008; van Teijlingen & Hundley, 2001; Woken, n.d.), including:

- Insight into hypothesis formulation and evolution
- Identification of new ideas, approaches, and clues
- Testing of interview procedures
- Experience for novice researchers
- Knowledge and experience in designing a research protocol
- Gauging the likely outcomes of proposed approaches to recruitment
- Collection of preliminary data
- Determining necessary resources
- Obtaining subject feedback regarding questions and interpretations
- Knowledge of where "Murphy's Law" will come into play
- Gauging time factors for interviews
- Assessing reliability and benefits/detriments of equipment

While the majority of the data for this study derived from archival research, the pilot study was beneficial in assisting the researcher in evaluating the likely outcomes of varied approaches to recruitment, important in this case as Dr. Mack died in 1974 and there are no identified surviving relatives. The researcher pilot-tested the interview questions in Appendix A with seven individuals who knew Dr. Mack in a relevant context, including colleague, former student, or both roles. Initial approaches to recruitment started with identification of potential interviewees. The identification process included following data threads at Pennsylvania State University and Texas Woman's University. The pilot study was highly beneficial in refining the interview process. The representativeness of the pilot sample became highly important, as Simon (2008) reminds us, because recruitment efforts indicated a smaller accessible population than envisioned.

Pilot Procedures

The procedural steps for this pilot study began with the submittal of requisite forms to Indiana University of Pennsylvania (IUP) Institutional Review Board to obtain pilot study permission. The researcher then proceeded to identify potential interviewees for the pilot study. She contacted the potential interviewees to identify candidates who were interested in participating and obtained signed informed consent forms. The researcher then arranged and conducted interviews. Following the interviews, the researcher verified information with the interviewees through member checking. After analyzing the interview data, the researcher decided to maintain the interview questions as crafted.

Ethical and Quality Considerations

Jacobson, Gewurtz, and Haydon (2007) examine the difficulties faced by social scientists who believe they are impacted by rules and regulations structuring ethics review. Researchers utilizing interpretive methodologies sometimes encounter problems when submitting proposals to research ethics committees who are unfamiliar with these types of methodologies. Tensions are also experienced by researchers employing study designs and processes shaped by what Jacobson and her coauthors refer to as an iterative interplay among research questions, data collection, and analysis. Approval of human subject research became standardized about three decades ago, with the structure and processes of ethics review being claimed by some to be negatively impacting scholarship because they are founded on assumptions deriving from biomedical research. However, federal and local levels have acted to protect the rights of research participants (Slavin, 2007) and the institutional review board (IRB) that exists in every university is charged with evaluating any risks that may be involved in a study. Member checking, taking themes and descriptions back to the interviewees for their perceptions of accuracy, and having others not connected with the study assess whether the findings resonate with them added to the trustworthiness of this study. The triangulation model deriving from social science, comparing findings from various sources such as interviews, document analysis, artifacts, and visual images, has as its central tenet an increased confidence in research outcomes when there are convergent findings (Moran-Ellis et al., 2006). This model was utilized in the researcher's study.

Data Analysis

The researcher utilized two methods in analyzing the pilot interview data for this study. The methodologies were assessed for viability in analyzing various types of archival documents, artifacts, and visual images. The first method, detailed by Kane and Trochim (2007), was the use of concept mapping. This conceptual methodology was examined in depth by the researcher for her Master's level work and aligns with the constructivist framework examined in Chapter II of this study, as well as with the constructivist-interpretive paradigm. As Kane and Trochim indicate, concept mapping emphasizes our construction of the world and maps the meanings we associate with the world. Concept mapping offers great potential to the researcher trying to make sense of mountainous amounts of data, with its framework for both organizing concepts as they emerge and also its ability to show relationships among concepts. Concept mapping, as noted by Kane and Trochim, is inherently a systems methodology and is helpful in articulating a model. Kane and Trochim acknowledge the vital role that concept mapping can play as a methodology that can facilitate learning, creativity, and adaptation. The analysis and organization of data from the interviews grew the concept map (Figure 18, p. 288) and revealed relationships and connections that were not as obvious in linear format.

Pattern matches use a ladder-graph type of representation to display comparison of different groups, variables, or points in time (Kane & Trochim, 2007). For this study, the researcher anticipated utilizing a variation of pattern match displays to analyze data across interviewee categories. In exploring Dr. Mack's life story, pattern matching was beneficial in assessing whether identified attributes, behaviors, and other concepts were

endemic to particular contexts. Pattern match displays were useful in the triangulation process as data from various sources were compared and contrasted.

Sample Narrative

Virginia Woolf (1882-1941), a novelist who also attempted literary biography, acknowledged that “writing lives is the devil” (as cited in Smith, 1994, p. 289), and lamented, "How can one make a life out of six cardboard boxes full of tailor's bills, love letters and old picture postcards?" (Christianson, 1994). The challenges of narrative writing have not abated. Chase (2008) recounts her difficulties in interpreting and representing as narrative her interviews with women school superintendents in the early 1990s. She points out that narrative inquiry in the social sciences is thriving, though she believes it is a field in the making. In her examination of several analytic lenses through which contemporary researchers approach narrative, Chase reminds us that narrative is retrospective meaning making, or the shaping or ordering of past experience, and delineates the following perspectives of narrative researchers (pp. 64-66): (a) oral or written narrative is treated as a distinct form of discourse; (b) narratives are verbal action, with narrators explaining, entertaining, informing, confirming, or challenging; (c) stories are both enabled and constrained by social resources and circumstances; (d) narratives are socially situated interactive performances, produced in a specific setting for a specific audience for specific reasons; and (e) narrative researchers are narrators, meaning that the previous four lenses are as applicable to the researcher as the researched. Narrative researchers are cognizant of the interrelatedness of these lenses and may emphasize different ones or alternate among them.

Chase (2008) portrays a range of diverse approaches utilized by narrative researchers, though she acknowledges the interdisciplinary nature of narrative inquiry. This study shares aspects of the two sociological approaches described by Chase, one of which is employed by sociologists who emphasize the identity work that people engage in across various contexts and the other which examines specific aspects of people's lives apart from organizational contexts. Gardner (personal communication, November 5, 2007) suggested that his portrait of Virginia Woolf (Gardner, 1997) might prove helpful. Gardner intersperses interpretation, biographical description, and primary source quotation to craft his portrayal of Woolf. He notes that there is "no single, privileged window peering into Woolf's introspective mind…. Only through a blending of insights and impressions from diaries, letters, essays, and fictions can one penetrate to the essence- or, more properly, the essences- of Virginia Woolf" (p. 90). Gardner succeeds in making a life out of Woolf's lamented "six cardboard boxes full of tailor's bills, love letters and old picture postcards" and provides a productive model for the aspiring narrative researcher in this case.

While the story of Dr. Pauline Beery Mack had yet to unfold for this researcher, the narrative presentation was anticipated to take the following form:

There are so many interconnecting storylines in life that I really shouldn't be surprised when the lines from one spill onto the pages of others, though I am still astonished when it happens. I stand here reading an article from the *Centre Daily Times* about a tiny girl who has osteogenesis imperfecta, otherwise known as brittle bone disorder. At five years of age, she has already experienced 70 broken bones. While reading about the challenges and routines of this spunky child who wishes she could

walk, I am startled when I realize that her mother is the archives record manager at Pennsylvania State University (PSU) who introduced me to a book neatly packed with a history of PSU's chemists. Flipping through the pages, a line in the book suggesting that a Dr. Pauline Beery Mack's dean was less than appreciative of her teaching style blipped on my radar screen. As a K-12 administrator cognizant of the numerous issues in recruiting, educating, and retaining individuals in STEM fields, I wondered about this Pauline Beery Mack, what her challenges and successes were, what her story might have to offer educational leaders facing a combination of old and new issues. Standing here, I think about the beginning of my journey into Dr. Mack's life story and the first document I read about her bone density studies. I think about the helpful archives record manager who serendipitously catalyzed my research quest into the life story of Dr. Pauline Beery Mack, a look back to move forward. And then I look at this article about the little girl who turns out to be the daughter of that same archives record manager, a little girl who undergoes four-hour infusions of the drug pamidronate to increase bone density….

CHAPTER IV

DR. PAULINE BEERY MACK'S STORY

Introduction

Case study researchers are faced with many methodological options, particularly when considering the presentation of biographical data. In view of Chase's (2008) struggles in interpreting and representing in narrative format, I reflected on her examination of narrative's role in shaping past experience. From the interrelated lenses she presents, the ones that resonated as most applicable to this study involved narrative as verbal action reflective of a socially situated interactive performance. With massive amounts of archival and other documents and data, what would be the most effective way to construct an accurate and compelling life story for the author's intended audience that would support the instrumental purposes of this case study? Construct turned out to be the key word.

The research design for this study reflects the constructivist-interpretive paradigm in its inquiry strategies and data collection methods (Denzin & Lincoln, 2005). In looking at the extensive documents and other items supporting this study, I was cognizant of the multiple realities contained within. In my quest to accurately understand and reconstruct Dr. Mack's life story, I would be seeking patterns that would be revealed in the reconstruction. With that view, I followed Smith's (1994) lead and built a chronological document archive. This chronological archive was then utilized to craft an interpretive biography, Creswell's preferred approach to biographical writing (1998).

When a biography is written from the interpretive view, the narrative reflects autobiographical glimpses of the writer (Creswell, 1998). The author is cognizant that her

particular biases and values cannot be totally isolated from the text. From this premise, I wrote Dr. Mack's life story as a chronology. Her life story was first framed with objective data acquired from archival and other documents. Stories garnered from those who knew Dr. Mack were then threaded in the appropriate chronological timeframe. Using the interpretive approach, I brought myself into the narrative and acknowledged my point of view.

As Dr. Mack's life story unfolded, I made the determination that interspersing interpretation and analysis would impinge upon the flow to work against readers' and the writer's construction of knowledge pertaining to unfolding patterns and emerging answers to the author's research questions. Therefore, Chapter IV contains Dr. Mack's life story as constructed from the author's interpretive approach. The resources used to build the author's archive and construct Dr. Mack's life story as presented in Chapter IV are contained in the Biographical Bibliography that follows the References section of this study. Chapter V contains the interpretive analysis of data. To fulfill the instrumental aspects of this case study, Chapter VI summarizes the study and presents conclusions and implications for secondary and tertiary educational leadership. Dr. Mack's life story, as constructed by the author, now unfolds.

Prologue

Six of us were there on that spring Sunday in 2008 in support of my quest. After a quick look at the vast expanse to be covered, we divvied up general starting points and headed out to separate sectors. Walking briskly, I scanned the ground and started to fret after what seemed an interminable amount of time that perhaps I had missed an area. My head snapped up at the sound of my husband's voice ringing out in triumph: "Over here. I

found it!" Sunlight, a somewhat rare commodity in State College, was waiting with my husband to reveal what I had been seeking. Cognition and emotion tangled as I bent down to gaze upon the plaque designating journey's end for Pauline Beery Mack. My thoughts drifted to my first awareness of her six months earlier.

My initial encounter with Pauline Beery Mack's name took place the preceding fall while I was visiting Penn State University's Paterno Library. An archives record manager showed me a book about Penn State chemists that she thought might interest me. While flipping through the pages, comments about Pauline Beery Mack's entertaining lectures engendering the disapproval of Dean Wendt captured my attention. My curiosity piqued, I sought out additional information. The more I discovered, the more I saw was waiting to be discovered. From rows of text in a book to a row of plaques in the cemetery, my desire to learn the complexities of this individual to the greatest extent possible solidified.

Crouching down, the first of many questions fired as I wondered how Pauline Beery Mack had found her way back to Centre County Memorial Park to be reunited with family members who had not lived to accompany her on the Texas leg of her life's journey: her parents, John Perry Beery (1862-1944) and Dora Woodford Beery (1864-1946), and her husband, Warren Bryan Mack (1896-1952). The answers to this and other more complex questions gradually revealed themselves as I followed her path from Pennsylvania to Texas and back, my journey to recreate hers in order to elicit the life story of this unique woman whose bifurcated history could be subtitled *A Tale of Two Universities*.

Figure 1. Area of Centre County Memorial Park where Pauline Beery Mack, her husband, and parents are interred. Photo by author, May 2008.

Figure 2. Pauline Beery Mack's memorial plaque, Centre County Memorial Park. Photo by author, May 2008.

Pauline's Formative Years

Childhood Roots

America's national tree, oak known for its strength, grows from a tiny acorn that can be rooted in a gallon container. Pauline Beery Mack's roots began in like fashion, in Norborne, Missouri, which spreads over a mere 0.63 square mile. Norborne B. Coats, a civil engineer who arrived in 1867 to negotiate railroad rights, was instrumental in germinating Pauline's hometown. Norborne was incorporated in 1874 and reorganized as a city of the fourth class in 1878. A railroad town at birth, Norborne was and is

primarily an agricultural community. January and Snoddy opened the first stock of goods in Norborne, which continues to be populated with many small businesses. One such small business in Norborne's early days was started by Pauline's father, John Beery. John opened a general store in Norborne following his studies at Eastman Business College in Poughkeepsie, New York. It was in Norborne that he met Dora Woodford, whose mother operated a hotel.

Dora Woodford, born on June 18, 1864 in Carroll County, Missouri, was the daughter of Harry Lee Woodford and Maria Jane Young. When she was a 2 ½-year-old, she relocated with her family by covered wagon to southwestern Kansas. This was a time when the government was opening up land in that area. Dora's family was among those who helped to establish the town of Oswego, Kansas. Harry Lee Woodford became the first general merchant in town. Dora, daughter of a merchant, married one.

Following their marriage, John and Dora continued to run the store that John had started. This was not a joint operation, however, as Pauline's parents kept their interests separate. John sold various goods, including millinery, while Dora's business was women's tailoring. John and Dora became parents of their only child, Pauline, on December 19, 1891, and proceeded to raise her in Beery's General Store. Pauline, whose name ironically derives from a Latin expression meaning small, quickly displayed the potential of a tiny acorn.

Childhood Memories

It is through the words of Pauline's husband, Warren Mack, that we learn something of Pauline's childhood. Pauline was a precocious child, with her mother confiding in Warren that Pauline spoke more than a few words before she was nine

months old. Pauline was insistent that her memory was constant from that time. Her first memory was of the sensations of pleasure in her new silk dress that she was dressed in to have her photograph taken. Pauline later told Jessie Ashby that her mother dressed her in prim and proper clothes as a child, wanting her to be the frilly girl that she could never have been.

Pauline's mother, Dora, lived up to her New England ancestral traditions. She was a strict disciplinarian who expected that Pauline, even as a young child, would work before playing. Pauline was little more than two years old when she was assigned her own special department in the family store: thread, ribbons, and millinery and dress trimmings. When it came to opportunities for playing with other little girls, Pauline had specified times for leaving and returning. Violating the schedule was grounds for punishment, though it might not be immediate. Consequences were announced, but following through on them took place at the convenience and appropriate mindset of her mother. Dora Woodford Beery's expectations for her daughter extended to her education as well. Though Pauline had much competition, she led her class throughout her public schooling. Nothing less would have been acceptable to her mother. Pauline also took music lessons in childhood, revealing great promise as a singer. The threads of her interest and talent in music can be discerned well into adulthood.

Pauline also developed a skillful habit in childhood. One of her teachers in school would hit Pauline's knuckles with a ruler when she used her fingers to add and subtract. That didn't deter Pauline from using her fingers in the adding and subtracting competitions that were held between schools. Of course she won. Pauline continued to use her fingers for adding and subtracting as an adult. She was really good at it and fast!

A Change in Direction

Pauline attended Norborne High School, where she pursued the classical course available at that time. She took four years of Latin, three years of German, and four years of mathematics. Norborne High School's girls' basketball team, on which Pauline was a forward, was undefeated for two years and ranked first in the state. In 1910 she proceeded to Missouri State University with the intention of majoring in Latin. However, Pauline did not make this trip alone. Her mother and chaperone, Dora Woodford Beery, went with her. Warren Mack speculated that Pauline's mother went along because she did not want to be separated from her daughter. There were benefits to this arrangement, though, as having a constant chaperone alleviated the elaborate rules pertaining to social activities among male and female students at that time. Pauline was able to associate with male and female friends to a degree that would have been impossible if she had resided in a girls' dormitory. While Pauline attended classes, her mother kept up with her tailoring business.

Pauline's college life did not begin smoothly, as she did not develop a rapport with the head of the Latin department, described as an elderly, acid-tempered spinster. Pauline received an M, for medium, on her first Latin quiz. Returning to her apartment, she discovered her mother had packed all their things to go back home. Why? Her mother had not taken her to the University to earn M grades. It was a good thing for Pauline that she had developed a rapport with the chemistry department head, Dr. Hermann Schlundt, and had earned an E (excellent grade) in chemistry. Together they convinced her mother to rescind her decision, providing Pauline with another opportunity. Pauline improved her Latin grade to an S (satisfactory), switched her major to chemistry, and became a lifelong

fan of Dr. Schlundt. Warren Mack, one day making Dr. Schlundt's acquaintance at an American Chemical Society meeting, discerned that Dr. Schlundt had a similar admiration for Pauline.

While completing her bachelor's degree in three years, Pauline played basketball until athletics gave way to the demands of academics, music, and socializing. Minoring in physiology, mathematics, and English, Pauline also became a student assistant in the physiology laboratory. Here she prepared materials and specimens for study. Even music and socializing became limited as she focused on her studies and work.

Pre-Collegiate Career Years

Pauline received an A.B. degree from Missouri State University in 1913. Following graduation, she returned to Norborne High School as a science teacher. Pauline faced some challenges as a novice teacher. Since she had only been at the University for three years, the high school senior class members were students who had been freshmen when Pauline was there as a senior. Discipline problems were resolved differently in the earlier part of the 20th century. There was no ban on corporal punishment at that time, assuming a student was not the offspring of a school director or other leading citizen. After an encounter with one of the larger male students, it is sufficient to say that Pauline had much less trouble enforcing discipline.

Two years later Pauline accepted a position as head of the science department of Webb City High School in Missouri. During her time in Webb City, Pauline learned about the problems of workers in lead mines, mine cave-ins, and smallpox. At work, she coached the girls' basketball team and, over her objections, also conducted the orchestra. The principal, noting that she could read music, told her to just have the students play

good and loud and bawl them out when they played the wrong notes. On weekends Pauline was able to study music under a capable teacher in Joplin who had coached opera singers in New York. She also sang in the choir of Joplin's Episcopal Church. Pauline attended Columbia University in the summers and continued her music studies there.

Pauline had some happy memories of Web City and her life with the family of a Dr. McBride. However, the limited opportunities present in Web City became apparent at the start of her third year. Pauline had purchased a dress for the express purpose of showing her chemistry students what the new rayon synthetic fabric looked like, though she did confess to selecting a flattering color, finish, and pattern. Her principal informed her that she had not been recommended for a raise, since she obviously didn't need it. His rationale? Anyone who could afford the luxury of an expensive dress certainly could not be in need of an increase in salary. Pauline determined to move on. With a limited supply of women science teachers and the entry of young men in the military, job options were plentiful.

In the summer of 1918 Pauline accepted an offer to become the head of the science department at Springfield High School in Missouri. She soon regretted this decision, as Dr. G. G. Pond of Penn State University approached her during her studies at Columbia with an invitation to come to Penn State. The school board in Springfield held her to her contract, so she fulfilled its terms and returned to Columbia to finish her Master of Arts degree. During this time she was selected for a recital in Carnegie Hall and declined an offer to become a member of the Metropolitan Opera Company chorus. Warren Mack noted that Pauline's voice had an extremely wide range and described its

quality as coloratura soprano. In the summer of 1919 Pauline headed to Penn State to begin what would be the first of two significant stops on her life journey.

Pauline Beery Mack's Penn State Years

The First of Two Universities

Historical perspective. The Penn State University that Pauline had been invited to was founded in 1855 as an agricultural college designed to promote scientific education and improve Pennsylvania agriculture. Frederick Watts, in the 1858 *Annual Report of the Farmer's High School*, clearly reveals the prevailing sentiments of the time: A new light is about to break upon the agricultural community. This Institution will afford a place where their sons may be educated to a fitness for a high position in any of the walks of life…

Originally named The Farmers' High School of Pennsylvania to distinguish it from private, classical colleges, Penn State's charter contained four objectives relating to teaching natural sciences, incorporating practical application of work, experimenting to add to the field of knowledge about agriculture, and protecting the state's industrial interests through educating its farmers. Frederick Watts, president of the State Agricultural Society, noted that science, art, and labor must be combined in pursuit of a fit education that would lead to desired outcomes. The school experienced many financial and organizational challenges in its formative years. Evan Pugh arrived from Europe in 1859 to assume the first presidency of Farmer's High School. Given the extent of instruction in mathematics and natural sciences and the amount of time required for graduating, in 1862 Pugh requested and received approval from the Court of Pennsylvania to change the school's name to The Agricultural College of Pennsylvania.

A series of presidents brought varied philosophies and academic reorganizations to the College. In 1871, the Agricultural College experienced another academic reorganization when Reverend James Calder became its fourth president in seven years. Calder also applied for a name change to more accurately reflect the new academic direction of the college. The Agricultural College of Pennsylvania became the Pennsylvania State College in 1874. Calder also initiated other significant changes. He was the former president of Hillsdale College in Michigan, one of the first co-educational colleges in America. He brought two co-eds with him in his determination to start co-education in Pennsylvania. The introduction of women did not have much effect on the chemistry classes at that time. Most of the women students in the 1870s pursued a classical course of study. The 1880s and 1890s saw female students more attracted to a "Ladies Course" than a scientific course of study.

In 1888, a New Englander who had studied in Germany arrived at Penn State to take on the role of professor of chemistry and chair of the department of chemistry. George Gilbert Pond was faced with the task of rebuilding a department that had seriously deteriorated since the death of Evan Pugh. In his 32 years at Penn State, dealing with financial constraints and lack of adequate space, Pond was both beloved and feared by his students. In 1893 he formulated a plan for the future of the chemistry department, providing the trustees with a list of seven proposed changes. He wanted to include manufacturing and industrial chemistry in the curriculum and he also wished to bring the field of textile chemistry into the classroom. As studies and research on dyeing, bleaching, coloring, and calico printing gained importance in the United States, Pond wanted Penn State's Chemistry Department to be on par with others.

A match. Pond's goals led him to Pauline Beery. Pauline Beery had specialized in physiological and textile chemistry. In reflecting on this time in her life, Pauline recalled, *"When I graduated from Columbia I wanted to go in for pure chemical research, but found this was still a man's field- now, of course, this has changed- so little by little I turned to the application of chemistry to medical, household and industrial problems"* (Pines, 1950). Pauline decided to accept Pond's invitation to come to Penn State. Pond's intention for hiring Pauline was to have her develop a chemistry program for women. This program would be built around applications in nutrition, dyestuffs, and home economics. Pauline was well-prepared to bring Pond's plan to fruition, having majored in physical chemistry under Dr. Kendall at Columbia and minored in physiological chemistry and nutrition under Dr. Sherman. She also had great interest and enthusiasm for these areas of study. Atypical of the time, Pauline became one of two women on the department's faculty when she arrived in 1919. She joined Mary Willard, a chemistry instructor who was born and raised on Penn State's campus. Mary would end up being one of the few from Penn State to attend Pauline's internment in 1974. Respect, friendship, and certainly Mary's cognizance of Pauline's foibles would characterize their relationship.

Pauline took on a demanding schedule, teaching 30 to 35 hours a week in addition to her independent research studies. She managed to tutor students on her own time, declining fees. During her years at Penn State, thousands of undergraduate students would end up attending her lectures. Pauline, a dynamic teacher, would become known as a colorful and entertaining personality. Her initial transition to Penn State, however, was not what she had expected when she accepted Pond's invitation.

Beginning With a Loss

Teacher Bertran Taylor, corresponding with Pauline from Kansas in the fall of 1919, had moved there from New York City. It is unclear whether he met Pauline while she was at Columbia or earlier, though he was cognizant of her Webb City days. In his correspondence to Pauline, he discussed his feelings about his girl, Lavinia. Taylor asked Pauline for both her and her mother's opinions of his lady. Even though Pauline did not see her very long, Taylor stated, "I know you have your opinion." Taylor wrote to Pauline that he would have a better future in Kansas than Missouri and also inquired as to whether or not Pauline ever heard from any of the Webb City teachers. In response to Pauline's question regarding what progress he was making, Taylor wrote: "The outcome looks good at present. But you understand. Things can look promising and there can be a change." That was the case for Pauline in Webb City. It was also to be the case early in her career at Penn State. Pauline was enjoying her early days at Penn State- Taylor responded to a letter from Pauline on November 9, 1919, telling her that he was certainly glad to know she was enjoying herself and liked her new location. However, circumstances soon changed. Pauline was not destined to have Dean Pond continue as her leader and friend. In May 1920 Pond unexpectedly passed away at the age of 57. Charles Stoddart, Dean of Liberal Arts, became acting dean. The search for a new dean commenced while the temporary dean maintained the status quo and offered no significant changes.

Figure 3. Pond Laboratories, Penn State. Photo by author, June 2008.

Forging ahead. With no assistance, and as her husband noted, frequently in spite of opposition, Pauline had to create her anticipated program. Pauline began her career at Penn State by teaching multiple sections of recitation and laboratory in freshman chemistry and some in organic chemistry. She immediately set to work outlining new courses in household chemistry. Miss Edith Chace, Director of the Department of Home Economics at Penn State, collaborated with Pauline on a course in practical application of chemistry to household problems. The course was instituted in 1922.

Since the girls in the department of home economics at Penn State had the same training as men in inorganic chemistry, organic chemistry, and qualitative analysis, they were well-versed in chemistry concepts. It appeared that the students ran into problems with the application of chemistry to problems in their field when they became high school home economics teachers. The girls were puzzled over simple matters. Either their training was lacking or something wasn't getting across to them. Miss Chace garnered questions through the mail, conducted interviews with the girls, held round-table discussions, and had various gatherings of high school teachers. She retained the questions she had gathered in anticipation of finding a solution. Pauline also had her own collection of practical questions that chemistry could solve. In a journal article describing the creation of this course, Pauline included a list of 25 questions from Miss Chace's

notes, which were among the 800 to 1000 that were collected before work started on the course. The diversity and practical nature of the questions are evident: *How may all-wool underwear be washed without shrinking? Why do we find soot on our cooking utensils? What is the composition of face powders and rouges and what is their effect on the skin? Why does the gas oven sometimes explode when lighted?* The ensuing course in household chemistry was scheduled for the second semester of the sophomore year. By that time the students would have taken the necessary one semester each of inorganic chemistry, organic chemistry, and qualitative analysis. A separate course was planned to address the problem of the relation of chemistry to the study of foods. This course would follow the more general course.

Propensity for authorship and collaboration revealed. Pauline wrote a textbook and laboratory manual for the courses, respectfully dedicating *Chemistry Applied to Home and Community* (1923) to the leader and friend she had lost, George Gilbert Pond. In the book's preface, Pauline noted that the book was intended to point out to college women the relation between the science of chemistry and the problems of her everyday life. Pauline also highlighted the changing times. Three generations earlier, women were primarily concerned with producing at home the items needed by her family. The modern woman, however, was now charged with choosing from among numerous factory-produced goods. Pauline stated that women should be taught about the composition, methods of refining, and properties of commonly used items so that they could wisely judge their value. Pauline acknowledged her gratitude to Miss Chace for the loan of the questions that helped to guide the selection of content for the text. Her friend and colleague, Mary Willard, checked the laboratory exercises for the textbook.

Dr. Hannah Honeywell, who would become one of Pauline's dissertation advisors, helped in critiquing and revising some of the chapters. Warren Mack's artistic talents supported Pauline's authorship, as he contributed pen drawings for her book.

Pauline also collaborated with Mary Willard during this time period. Their lengthy article on the history of dyes was segmented in the March, April, and May 1923 issues of *The Journal of Home Economics*. Pauline and Mary presented typical theories explaining the origin of textile fabric dyeing (imitation, sexual attraction, and rank) and discussed Slosson's position that there were three distinct developmental stages in every industry engaged in by man: appropriative period, adaptive period, and the creative period. Primitive man met his needs by appropriating from nature. In the next cultural stage, man improved upon the appropriated material so that it better met the intended need. When the need surpassed nature's supply, man pursued the creation of an artificial substitute. Pauline and Mary used this stage of progress framework to explore ancient and modern origins of dyestuffs and the dye industry.

In tracing the evolution of the dye industry, Pauline and Mary noted that scientific research had produced a revolution in the history of applied science. The vast number of distinct synthetic dyestuffs marketed at the time of their article was a direct result of inventive man pursuing the preparation of artificial substitutes for nature's materials. The chemist, intent on reducing the cost of dye production to dyes that would be attainable by all, researched the chemical composition of commercially important natural dyes in order to synthetically build a compound. Man succeeded in this creative period, with synthetic products superior to natural as regards purity and uniformity of composition.

During the lengthy search period for Pond's successor, Pauline and Mary Willard were two of several Penn State chemists who submitted a petition to the American Chemical Society to create their own division. Though eight counties formed the Central Pennsylvania Section, 42 of the initial 60 members lived in State College. The first meeting was held on March 12, 1924, the same year that Pond's successor was finally found. Gerald Wendt, experienced in chemistry and physics and with industrial experience at Standard Oil, became Dean of the School of Chemistry and Physics in 1924. Pauline Beery Mack finally had a new leader, though one who may not have appreciated all her talents.

A Fortuitous Introduction

Engaging minds. While Taylor was corresponding with Pauline regarding his relationship with a girl who had never been out of New York City, something he found hard to conceive, Pauline was forming her own relationship. October 1919 brought with it a highly significant event in Pauline's life, though it certainly did not seem so to her at the moment! Fred Hosler, who later became superintendent of schools in Allentown, Pennsylvania, introduced Warren Mack to Pauline. Fred was engaged to Mildred Seeley, who was living in the same dormitory as Pauline, Maple Lodge. Pauline chaperoned the dormitory in exchange for lodging there and board at McAllister Hall. The girls in the dormitory made plans for a Saturday afternoon hike and picnic supper. Any boy-girl activity required chaperoning in those days, so Pauline was invited. Fred, who had met Warren in classes, suggested to the group that Warren should be invited. Fred thought he would be perfect at diverting Pauline's attention since both Warren and Pauline were Phi

Beta Kappa members and would certainly become rapidly absorbed in learned discussions! The group concurred and Warren was invited.

Pauline, on the other hand, was seriously wishing that the girls had never conceived the idea of a hike. After she had agreed to chaperone the girls, a colleague in the chemistry department, Ray Bostock, invited Pauline to attend a University Club dinner dance with him. Despite wanting to go to the dance, Pauline kept her commitment to chaperone. The group held their party at a small Boy Scout cabin just north of State College. Pauline, having come to grips with the postponement of the University Club date, had a good time along with the rest of the group. One could infer that Fred was correct in his assumption about this meeting of the minds, as Pauline and Warren became engaged approximately five months later.

Engaged soon after meeting, Pauline and Warren did not marry until four years later. Though economic considerations on Warren's part played a role, the delay was also due to Pauline's desire to continue her professional work. In order for her to do this, she and Warren needed to be working at the same location. While Warren had been offered a position at Penn State prior to receiving his degree, the offer was withdrawn upon the typical occurrence of appropriation receipts coming in below expectations. Warren accepted a position at Massachusetts Agricultural College. He and Pauline postponed getting married until he received an appointment in Horticulture at Penn State in 1923.

Warren's words regarding Pauline's professional drive reveal his awareness, acceptance, and depth of feeling: "Pauline never wished to become a housewife, because, as she argued, she did not like housework and cooking, and had not trained herself for them; she enjoyed her professional work, and had spent considerable time and money in

preparing herself for it. I think I should have agreed to any terms whatsoever." In the summer of 1923 Pauline traveled to Europe with her mother and Aunt Nina Woodford. It was there that she bought her trousseau, one piece of which became a special tradition. After their wedding on December 27, 1923, Pauline's hand-made Brussels lace wedding veil was subsequently worn by many of her graduate students at their weddings.
Jean Sherrill, one of Pauline's students who later worked for her, wore Pauline's veil when she married. She described it to me as being very long and beautiful, which is certainly confirmed by the photo. Warren Mack took Jean and Joe Sherrill's wedding photos, including the one with her wearing the veil.

Figure 4. Joe Sherrill and Jean wearing Pauline's veil. Photo courtesy of Jean Sherrill.

Warren Bryan Mack. Pauline's husband would attain world-wide recognition of his own through his work in horticulture and the graphic arts. He was a Pennsylvanian, born in Flicksville in 1896. He was slightly more than four years younger than Pauline. Warren earned a Ph.B. from Lafayette College and became a high school science teacher, a path similar to Pauline's. He taught in Manasquan, N. J. from 1915-1918 and then worked in the labs at New York Edison Company for a year. He subsequently earned a B.S. in Horticulture from Penn State in 1921, an M.S. at Massachusetts Agricultural

College in 1924, and a Ph.D. in Plant Physiology from Johns Hopkins University in 1929. At Penn State, his career progressed from Assistant Professor in 1924 to Professor of Horticulture in 1944. Warren became head of the Department of Horticulture at Penn State in 1937. Dr. Walter Thomas and Warren collaborated on extensive research in plant nutrition. Warren authored or co-authored many technical, trade, and popular articles on topics ranging from plant nutrition and commercial vegetable production to home gardening. Actively engaged in many organizations, he served as a president of the American Society of Horticultural Sciences. He was also a fellow of the American Association for the Advancement of Science.

Self-taught as an artist, Warren took up drawing at the age of five. At ten, he was able to create a recognizable sketching of his baby sister. While growing up, he also developed an interest in the construction of wooden sleds, carts, and other playthings, thereby learning the qualities of wood. About the same year Warren met Pauline, an exhibit of the wood engraving process in the New York Public Library sparked a combination of his boyhood interests. In 1927 he completed his first original wood engraving, *Winter Night in Washington*. The magazine of the Sunday Baltimore Sun published it in 1929. Warren's realistic prints would end up in the collections of several prominent institutions: Fogg Art Museum of Harvard University, Baltimore Art Museum, The Library of Congress, the Metropolitan Museum of Art, and the Hunterian Art Gallery at Glasgow University in Scotland. In 1944 Warren's artistic and professional talents were recognized with the unusual distinction of elections to the National Academy of Design and the presidency of the American Society of Horticultural Science.

Warren's personality is revealed in part by those who knew him through his printmaking. Gene Lederer, who served as Acting Burgess of State College from January 1930 to July 1932, suggested that Warren's gentle personality was reflected in his finely wrought pastoral scenes and peaceful landscapes. Lederer referred to Warren as a sensitive and gifted man. John Taylor Arms (1887-1953), who was a renowned printmaker and chairman of the Graphic Art Section of the National Academy of Design, nominated Warren as an associate of the Academy in 1944. In his nomination letter, he referred to Warren as a fine and sympathetic man.

Warren's gentle personality contrasted with his wife's take-command demeanor. Jean Sherrill, a former student and later secretary to Pauline, told me about this contrast as well. Warren was charming, but not effusive like Pauline. He also had the patience of a saint. This was particularly evident in the demands of taking care of Pauline's parents in their later years when they came to live with them. Helen Ludeman, who was a faculty member at Texas State College for Women, met Warren on his trips there. To her, Warren was a fine fellow. He was feminine, not in looks, but in the manner of what he did. Pauline, on the other hand, was very masculine. Helen, along with many others, noted that Pauline could curse. Her language did mellow in her final years.

One can picture this talented artist and scientist, sitting at the table during one of many dinners held on the Penn State campus. As they went around the table for introductions, Warren would introduce himself: *"I'm Dr. Mack's husband."* Pauline and Warren, two highly talented individuals with many shared interests and somewhat opposite personalities, built an inseparable relationship until an untimely death.

Pauline and Warren had an open house one time, with decorations of pink and blue ribbons. One of the deans said to George Vose, *"Do you think that she is pregnant?"* That was not the case and the Macks never had any children. They never talked about it in front of George, leaving him to speculate that perhaps Pauline and Warren were too busy. Pauline's former secretary, Jean Sherrill, said that Pauline told her she could not have any children. Pauline thought it had something to do with her participation in sports in her earlier years.

Mixed Reactions to Professor Mrs. Mack

Supervisory versus student perspectives. Dean Wendt, in his reorganization of Penn State chemistry, changed the traditional course numbering system used by Pond, in which first-year students took 100-level courses, second-year students took 200-level courses, and so on. In Wendt's new system, chemistry courses were numbered by subject. Inorganic chemistry courses were numbered 1-10 and 11-19 were used for chemical education and history. The 50s were reserved for applied chemistry classes. The amusing and spirited *Professor Mrs. Mack* taught Chem. 52, Household Chemistry. A dedicated researcher and devoted teacher, Pauline was renowned for her entertaining lectures. One student likened her to Will Rogers due to her down-to-earthness and humanness, believing that there was no instance in which she would fail to enjoy herself or find something worthwhile.

Jean Sherrill, who graduated in 1939 with a degree in home economics, was one of Pauline's students. Pauline was the primary lecturer for the undergraduate chemistry courses the students were required to take. Jean, recalling large classes of perhaps more than fifty to sixty students, told me that Pauline had a reputation for being flamboyant.

Noting that Pauline was a fun person to listen to, she remembered that "things exploded!" Professor Mack obviously knew how to get her students' attention in these weekly lectures!

Dean Wendt was not so similarly taken with Pauline's style. In a letter written to F. C. Whitmore in July of 1930, he remarked that the students liked Mack in part because of her personality and in part because she gave them material that was spectacular, superficial, and quite easy. Wendt noted that she showed students lots of pictures, read them the funny papers, and did anything to interest and amuse them. To him, it was nearly nothing that the student could take with him as an education. According to Wendt, it was more a circus than a college course. As vaudeville it would have been a hit and as a high school course it would be fair. As a serious college course, he called it a disgrace. Yet at their 10th reunion, the class of 1923 voted Pauline as their most inspiring teacher, an honor as significant to Pauline as many of the others she received during her years at Penn State. Pauline generated contrasting viewpoints throughout her career, none of which appear to be ambivalent!

Colleagues' responses to Ph.D. While Dean George Gilbert Pond's primary focus had been on educating and preparing for research, he and his staff did not attend to carrying out research. Pond's faculty, due to a lack of funds, had a dearth of professors with advanced degrees. Dean Wendt had other ideas, wanting his faculty members to devote more time to research responsibilities and less time to teaching responsibilities. He also strongly desired that his faculty members would have doctorates in chemistry. Though no doctorate program in science existed when Wendt became dean, two years later, in 1926, Marsh White became the first to earn a Penn State Ph.D. The first

doctorate in chemistry was earned in 1928 by John Edward Snyder. The first woman to earn a scientific doctorate at Penn State was Pauline Beery Mack, with her 1932 degree in Agricultural Biochemistry. Pauline came face to face with the complexities of human nature in the varied responses of her colleagues during her doctoral research.

Pauline's position on nutrition was that human beings were the appropriate subjects for the study of human nutrition. However, she recognized the value of laboratory animals in discovering basic principles and processes. Ten years after coming to Penn State, she began doctoral research studies involving the effects of radiant energy of different frequencies on calcification in bones of young rats. Pauline had both individual and organizational support for her research. Lloyd T. Devore lent Pauline some special pieces of optical apparatus he had designed and also helped in their manipulation. General Electric Company provided lamps, bulbs, and a caesium [sic] photo-electric cell, and National Carbon Company loaned Pauline a Coblentz galvanometer.

Dr. Hannah Honeywell from the Department of Agricultural and Biological Chemistry initially supervised Pauline's doctoral research. Pauline's studies progressed well for a year or so, until Dr. Honeywell married and left her profession. Warren Mack indicated that Dr. Honeywell's successor was not interested in Pauline's studies and was not prepared to direct them. In fact, the successor expended great energy and ingenuity while trying to discourage Pauline from her studies. Pauline later confided in George Vose, a future colleague and friend, that when she was studying the lab rats under different spectrum lights, more than one individual turned the lights on during her

experiment when they should not have. George thought the male chemistry professors at Penn State were jealous, seeing Pauline outpace them in her research.

Pauline persevered during this tumultuous time, turning to the Department of Physics and Dr. David C. Duncan, who provided a combination of sympathy and help with dealing with the light sources and the transmission of filters. Ernest Axman contributed technical assistance. Warren Mack notes that with Axman's assistance, Pauline completed her dissertation in 1932. Pauline also acknowledged the vital contributions of her husband, noting that without Warren's helpful advice and constant assistance it would have been impossible to complete her study. Warren was not the only family member who contributed to Pauline's dissertation endeavors. Pauline's mother, Dora Woodford Beery, helped with the mounting of illustrative material and the preparation of her manuscript. The end result, after help and hindrances, was a stellar contribution in the eyes of Dr. Duncan. He referred to Pauline's work as one of the most brilliant dissertations in his awareness. Pauline's accomplishment was not universally acknowledged, though. In spite of the fact that she had earned her doctorate, some of Pauline's male colleagues continued to call her Mrs. Mack.

Life in State College

Pauline Gracia Beery was confirmed in St. Andrew's Episcopal Church on April 11, 1920, around the time that she was corresponding with her 76-year-old cousin. Pauline had written to him in search of information regarding the history of the Woodford and Woodruff families in America. He informed Pauline that he had not been able to locate information that would connect Pauline and him to Revolutionary sires. Soon after his discharge from the Union army, Pauline's cousin had visited his nearly ninety-year-

old Grandmother Woodford, who gave him a great deal of family history. Unfortunately, he acknowledged that at that time he was a wild young chap and did not write down what she told him. Much of it he had forgotten over the years. He did remember that she told him that he and Pauline were direct descendents of Captain Joseph Woodford of Washington's army, though he had yet to verify that connection.

Family Matters

Pauline's mother was able to help with her dissertation manuscript because Pauline had persuaded her parents to move to State College in 1925. Her parents were active, healthy, and so busy with their business in Norborne, Missouri that they had little opportunity to visit State College. Pauline and Warren were occupied with their work at Penn State and found it difficult to travel to Missouri. Given the close relationship that Pauline had with her parents, the move is not surprising. Jean Sherrill, Pauline's student and subsequent secretary, recalled that Pauline was the apple of her parents' eyes, with the sun rising and setting on her. It was reciprocal. Pauline's father went on a trip to Europe and she and her mother took care of selling the store in Missouri.

Pauline and Warren had opened up a gift and art shop in 1924 in State College, the Old Main Art Shop, which Pauline's mother took over after the move and successfully ran until her retirement. Pauline's father sometimes helped at the store, but contributed increasingly greater amounts of time with the clerical work for another of Pauline's endeavors, *The Chemistry Leaflet*.

Outreach Endeavors

Pauline's sphere of interest and work reached far beyond the Penn State campus. She pursued varied endeavors to engage others in science. She devoted time, energy, and

personal funds to support the chemistry education of high school students and to engender interest in pursuing involvement in the field. Pauline was proactive in attempts to interest and engage the general public. As an advocate for the consumer, Pauline strove to support an informed citizenry.

Supporting High School Science

Publication history. Pauline was greatly interested in any effort that would explain science and inspire a scientific attitude among people, especially youth. In an effort to interest beginning students in chemistry and its applications to their own problems, Pauline founded *The Chemistry Leaflet* in 1927. She subsidized the publication with her own funds in the beginning. In a few years, there were enough subscribers to take care of the publication costs, but not to compensate Pauline for her efforts. Francis Garvan, a United States Alien Property Custodian, who contributed money to chemical education through the American Chemical Society Division of Chemical Education (DIVCHED), urged DIVCHED to publish *The Chemistry Leaflet*. The Society published *The Chemistry Leaflet* as one of its official periodicals, subsidized by the Chemical Foundation, Inc. DIVCHED had three continuing concerns: sustained service to high school teachers, participation of university and industrials leaders in DIVCHED, and women in chemical education. The *Chemistry Leaflet* was known as the *Science Leaflet* in 1936.

The Chemical Foundation, Inc. was formed by Garvan and his fellow Alien Property Custodian, Alexander Mitchell Palmer, to make sure that access to certain chemicals existed for people in the United States. During World War I, German companies maintained a virtual monopoly on the production of synthetic organic

chemicals, including dyestuffs and related pharmaceutical products. After Germany had cut off the supplies of chemicals, the only effective antisyphilitic, Salvarsan, was nearly impossible to obtain. The foundation, as a trustee of the U.S. chemical industry, was supposed to Americanize and advance the industry. Controversy over the foundation's purchase of seized German patents resulted in litigation from 1922 to 1924, in which Garvan and the foundation ultimately prevailed. The foundation financially supported chemistry in general and the American Chemical Society specifically, subsidizing the publication of *The Journal of Physical Chemistry* and the *Journal of Chemical Education* for many years. Chemistry books published by the foundation were provided at or below cost to thousands of libraries, schools, and teachers. According to Warren Mack, funds dried up when the German chemical patents expired and the foundation dissolved. Pauline resumed the business management of *The Chemistry Leaflet*.

Pauline was able to garner substantial assistance and support for *The Chemistry Leaflet*, including encouragement and support from the head of the Department of Chemistry at Penn State, Dr. Frank C. Whitmore. With clerical help from her father and other individuals, Pauline continued her publication until the death of her father in 1944. John Beery worked with his daughter on the *Leaflet's* editorial details, while Pauline's mother handled subscription and accounting aspects. The staff of the Ellen H. Richards Institute participated in the editing of the publication. Jean Sherrill notes that all sorts of people were involved in supporting the publication. When she was Pauline's secretary, she would take items to the printer. Then there was Warren. Pauline's husband was a major collaborator throughout the *Leaflet's* lifespan. Pauline, in a March 1944 letter to Penn State Assistant Librarian Gladys Cranmer, responded to a request for back volumes

of *The Chemistry Leaflet*. Pauline noted that she had been saving complete volumes to have bound for the library while concurrently having the remaining material produced by Warren and her bound. The husband-wife team of scientists wished to *"bind all of our stuff uniformly."*

Faced with a growing intellectual family with burgeoning time demands and the loss of her father, Pauline sold the publication in 1944 to Science Service for one dollar. Science Service published it as a monthly pocket magazine, *Chemistry.* Pauline G. Beery, Editor, became Pauline Beery Mack, Consulting Editor. Science Service continued to publish *Chemistry* through 1961, at which time it was purchased by the American Chemical Society (ACS). ACS continued the publication until it became a short-lived, general science magazine, *SciQuest*, in 1979. In 2004, John Moore from the University of Wisconsin-Madison expressed interest in scanning and digitizing the issues of *The Chemistry Leaflet* for on-line access. Impressed with the amount of relevant, fascinating, and timely information to illuminate chemical principles and facts that Pauline was able to gather, Moore also was interested in garnering volunteers to do a web-based version of *The Chemistry Leaflet* for today's students.

Leaflet content. Pauline was inconsistent in the use of her married name during the 1920s and early 1930s. Her work sometimes reflected her maiden name, Pauline Beery, and sometimes her married name in conjunction with her maiden name, Pauline Beery Mack. In this case, contributions for publication in *The Chemistry Leaflet* were to be sent to Pauline G. Beery at Penn State. Students in every state and five foreign countries received the issues, which cost $2.00 total in 1929 for 34 weekly issues. Each of the 34 issues published in an academic year aligned with the curriculum of the times,

which consisted mainly of descriptive and practical chemistry of the elements. For instance, high school chemistry in 1927-1928 included topics such as hydrogen, oxygen, and their compounds; states of matter; chlorine and its compounds; the other halogens; acids, bases, and salts; the Periodic Table; and platinum, osmium, and iridium. The *Chemistry Leaflet* incorporated ancient, modern, and current tidbits of information about the topics currently under study. When students were studying oxygen, the corresponding *Chemistry Leaflet* topics ranged from bees as the heaviest consumers of oxygen in proportion to their weight, to Joseph Priestley's personal account of his discovery of oxygen, to a denouncing of the use of pure oxygen by athletes.

Quotes from Jane Marcet's *Conversations on Chemistry*, first published in 1805, also populated the pages of the *Leaflet*. Marcet, intent on explaining chemistry with clarity and directness, used three fictional characters to achieve her goal: Mrs. B., the teacher, and two interested and excited pupils, Emily and Caroline. Marcet, herself not a chemist, particularly intended to reach females through her introduction to chemistry. Pauline, in publishing quotes from Marcet, reflected a similar objective.

The April 3, 1930 issue of *The Chemistry Leaflet*, which was billed as the only chemical publication devoted exclusively to the interests of students taking chemistry for the first time, was dedicated to the metal nickel. The reader learns about the versatility of nickel alloys and the application of nickel and a nickel alloy known as Monel Metal in the dry-cleaning process. A section entitled Nickel Notes includes numerous examples of nickel applications- tanks lined with Monel Metal sheet for melting chocolate, the use of Monel Metal wire by the Chicago, Burlington & Quincy Railroad in connection with a signal device on a bridge across the river at Kansas City, and the use of Monel Metal

sheet for paneling the lower part of the walls in a butcher's enterprise for purposes of appearance and sanitation. The emphasis is on everyday practical application, or as today's educators would phrase it, relevance. This issue also contained a section on miscellaneous metal notes, serving as a review of topics previously published. Pauline, dedicated to attracting more students to chemistry, added zest to the standard curriculum of the day.

Student Science Clubs of America and National Broadcasting (NBC). Pauline adjusted her microphone on this November day in 1936. As editor of the *Science Leaflet* (formerly the *Chemistry Leaflet*), she had made the publication the news organ of the Student Science Clubs of America. She had guided the development of the clubs, which were an educational project of the Chemical Foundation, Inc. Friendship, inspiration, and support for Pauline's club endeavors and other projects came from a diverse group: MIT President Dr. Karl Taylor Compton, Dr. Otis Caldwell, formerly of Columbia University and the executive committee of the American Association for the Advancement of Science, Dr. R. A. Millikan of the California Institute of Technology,
Mr. Franklin Dunham, Educational Director of the National Broadcasting Company, and Dr. E. E. Slosson, founder of Science Service.

On this day, Pauline prepared to interview Dr. Icie Macy, Director of Research of the Children's Fund of Michigan. The talk was the second of the current academic year in a series sponsored by The Student Science Clubs of America on science in daily life. Today's specific topic was the relationship of science to children's health. The interview would be broadcast over NBC's Red Network on WEAF and affiliates. Pauline addressed the unseen audience: …*Members of the Student Science Clubs of America, and other*

friends who are interested in the importance of science in the health of children. I am known to you as Pauline G. Beery, Editor of the Science Leaflet, and sponsor of your student club organization, of which Dr. Karl T. Compton is the president. … Dr. Macy will you kindly tell us of what your work consists as Director of Research in a great institution devoted to the promotion of the health and happiness of children? One of the questions Pauline proceeded to ask Dr. Macy that day pertained to whether mothers and others could readily perceive the failure of a child to grow properly. Dr. Macy replied that the difficulty with faulty nutrition was that its undermining of health was typically not prompt or spectacular. The results were usually felt so gradually that the cause was not readily evident.

The interview progressed as Pauline and Icie continued their question and answer rhythm. Pauline queried as to how the science clubs in high schools and colleges could help in disseminating information about improving diets in general, and particularly those of children. Icie responded that members should start by learning the facts and applying them to themselves. Before getting into the effects of injudicious dieting, Icie pointed out a truism that resonates today: *It is smart and thrifty to be healthy these days*.

As the interview was coming to a close, Pauline snuck in one more question. Dr. Macy was the first woman to address an audience on this program. Pauline asked the question that she said came to her over and over again from girls across the country. *Do you think that many girls should choose science as their profession?* In her reply, Dr. Macy noted that there was no specific reason why a well-gifted girl should not enter the field if she couldn't talk herself out of it. She had better make sure that the wish to become a scientist was not just a fancy, given the many years of difficult training that

would be required. Icie acknowledged the success of young women in areas related to women's problems such as nutrition and textile chemistry. She also noted that some women had made good in areas not pertaining to applications to women's interests. Her closing statement spoke to the attributes necessary to succeed in the realm of science: *It is not wise for many girls to rush into science as a life's work, however, and anyone choosing this field, as mentioned before, must be perfectly sure that she has the type of mental equipment required, an ironclad physical constitution, and an interest in the subject which will not permit her to be talked out of tackling it as a lifetime's job*. One could intuit that Icie, as a scientist in the field of nutrition, and Pauline, a research scientist in textile and nutrition chemistry, had the requisite mental equipment, constitution, and unfailing interest.

Nearly a year and a half later, Pauline travelled to the studios of KYW in Philadelphia for the 6th broadcast of the current academic year sponsored by the Student Science Clubs of America and NBC. By now, Student Science Clubs of America had grown to an affiliation of almost 800 high school and college clubs across the United States and Canada. The topic of this April 20, 1938 radio program was the research on child nutrition taking place at Penn State in collaboration with the Pennsylvania Department of Health. Pauline, as the interrogator, welcomed some high profile guests: Dr. Leo C. Mundy, who had authored and sponsored the Mundy Bill which provided the special funds for the study; Dr. Edith MacBride-Dexter, Secretary of Health of Pennsylvania; and the Honorable George H. Earle, Governor of Pennsylvania and supporter of the focus of the project, the improvement of children's nutritional well-being. Dr. Mundy answered questions pertaining to his bill and the preliminary research

that had taken place. He deferred to Dr. MacBride-Dexter, who addressed the topic of how the results of the study would be made useful to children. Dr. MacBride-Dexter discussed the nutritionists on the staff of the Department of Health and their duty to supervise the daily distribution of vitamin products by public school teachers to children suffering from malnutrition whose families were financially unable to provide such products. The nutritionists also taught classes for mothers and advised on the selection and preparation of food with great nutritional value.

Governor Earle, during the interview, stated that he was a layman with great interest in the nutritional research. He was particularly interested in the development of tests that take the guesswork out of whether or not an individual was well-off nutritionally. The interview provided an opportunity for Governor Earle to obtain some first-hand knowledge of the research, as Pauline presented two children from Altoona who had participated in the studies, Lawrence Canan and Josephine Gates. Lawrence described his testing for the Governor, stating that they measured him all over to find out whether his proportions were good. He also told the Governor about his tests for the condition of his muscles, the strength of his tiny blood vessel walls, the amount of coloring matter in his blood, and his eye test to determine if he had enough Vitamin A in his diet. Lawrence enjoyed all of the tests, believing the eye test to be the most fun. Pauline provided some information about the test and pointed out that Lawrence was a faithful milk drinker who liked carrots and other vegetables high in Vitamin A. Josephine took exception to the hemoglobin test, though she acknowledged that it was not really that bad: *A little instrument which felt like the bite of a huge mosquito was used to take a tiny drop of blood from my finger*. Josephine stated that she was told the test would show

whether or not she had been getting enough iron from her food. When Governor Earle asked her about the results of her tests, Josephine said that all she knew was that they gave her some tablets which had vitamins and minerals in them and they also told all the children to drink lots of milk, eat some meat daily, and to eat lots of fruits and vegetables. Lawrence and Josephine seemingly represented positive and less than positive nutritional states, since Lawrence had a perfect set of teeth and nearly a perfect score in all of his tests and Josephine was supplied with tablets. Governor Earle thought that children were fortunate to be born in a time when guesswork was removed from a fundamental problem, that of diet.

Growing Women's Knowledge of Chemistry

In the summer of 1930, the Division of Chemical Education of the American Chemical Society announced plans to develop widespread knowledge of chemistry among women and to reshape science teaching in schools and colleges.

Dr. Harrison Hale, University of Arkansas, was chairing a committee established to direct the organization of study groups in women's clubs in every state to facilitate a more popular understanding of chemistry among women. Newly elected Pauline Beery Mack joined his committee. Financial support for the women's club study course came from Francis Garvan, president of the Chemical Foundation. The study program encompassed twelve topics in the general field of American chemistry and emphasized the importance of chemistry in American life. *Feeding the Family* was one of the twelve topics. While engaged in this study, women students would use their critical thinking skills in criticizing constructively the types of food used by families of different socioeconomic circumstances.

Reaching the General Population

The title of one of Pauline's books reflects her attempt to garner the interest of the general population- *Stuff, The Story of Materials in the Service of Man* (1930). The title caught my attention, as during my years as a fifth-grade teacher I was rather tenacious in not allowing my students to get by with using the nonspecific term "stuff." In fact, a reflection written a decade ago by one of my former students that describes our classroom underscores that the message was received: "Basically, the room was just *packed* with stuff. (I know Mrs. B would be mad at me for saying the word "stuff," but it's the only word that describes everything in our room.)" Pauline was of similar mind when it came to life, as she noted that much of life is the strife for stuff. The major difference between those who are hungry and those who are well-fed, those who are homeless and those who are well-housed, those who are poor and those who are wealthy- amounts to stuff. Pauline drew the relationship to the individual's struggle for stuff in a lifespan to the similar struggle of mankind throughout history. She informed the reader that man's progress from one age to another depended upon the quantity of materials that are able to be secured and utilized. Much of our history, Pauline indicated, is the story of our search for the stuff which will be of service to us. She explicitly informed her readers that the diverse and extensive topics in *Stuff* were intended for every individual, whether age eight or eighty, who had an interest in the romantic story of the stuff used in daily life. Poetry, a one-act play on the Halogens, a diversity of quotations, and extensive illustrations, including some of Warren Mack's art work, mirror the diversity of methods Pauline used to engage her students in class.

Beginning with a royal family in ancient times and ending with the stuff of the future, Pauline addressed an eclectic mixture of stuff, including air, water, halogens, food, hot stuff, cold stuff, weather, textiles from test tubes, the science of stuff, skillets and skyscrapers, noble stuff, and sociable stuff. Sociable stuff, by the way, does not pertain to entertaining. In noting that some metals do not behave in the aloof manner that is characteristic of the so-called noble metals, Pauline was referring to sociable metals that are found in nature only in chemical combination with other elements. Pauline adeptly wove the science of the time with historical perspectives and tales in an entertaining and readable style, as illustrated by her portrayal of salt, a subtopic in the sociable stuff chapter. Pauline included information about salt's role in ancient Chinese and Roman superstitions and religious rites and segued to the medieval practice of the saltcellar on the table serving as the dividing line of social standing. We learn about the importance of salt through her questioning of a line in the *Odyssey*. Pauline then took the reader to the Big Bone salt lick in Boone County, Kentucky, speculating about the reasons for the vast number of skeletons buried in the vicinity. From there we learn about *salary*, a derivation of the word salt, and salt money. Pauline also addressed ancient traffic in salt, the source of salt, salt mining, and tax on salt. In just one small segment of this text, the reader gains knowledge of the science of salt, a common compound consisting of sodium and chloride, its sources, and also attains perspective on salt's role in history.

Pauline wrapped up her text for the common reader with a discussion of the stuff of the future. She addressed concerns regarding the depletion of our natural resources and the roles of scientists and nonscientists. A look at the lowly peanut hull illustrated what

Pauline saw as the twofold lesson of the potential of scientific research and the necessity for conserving raw materials. The hull, once the bane of small town motion picture janitors, was perceived to be potential raw material for building and textile trades, which would make the hull of greater importance than the peanut it contained. Pauline highlighted recent advances in science, with the artificial distinctions between chemistry as the science of materials and physics as the science of energy appearing to diminish. She pointed out that our hunt for materials may be more thoroughly bound up with our quest for energy than previously thought, concluding that man will continue to gauge his progress by the stuff he learns to make and use and the energy he learns to harness. The common reader of the 1930s is left to ponder her seemingly prescient conclusion.

Revisiting the Work of George Gilbert Pond

In 1931 P. G. B. Mack published a rewritten and edited fourth edition of *Calcium Carbide and Acetylene*, a bulletin of the Penn State School of Physics and Chemistry. The author of the first three editions was none other than George Gilbert Pond, the Dean who had invited Pauline to come to Penn State in the year before his untimely death. The original bulletin was issued in 1900, the second in 1909, and the third in 1917.

Dean Pond had written the first edition following a request from the Pennsylvania State Department of Agriculture that he investigate the recently discovered gas, acetylene. The question was whether acetylene should be recommended to Pennsylvania farmers for house-lighting. Pond enthusiastically believed that creative man had invented a synthetic product that would offer farmers similar comforts and advantages as individuals residing in cities. Pauline produced the fourth edition because of the demand for copies of the no-longer available third edition and because of the extensive changes that had taken place in

the calcium carbide and acetylene industries in the years since 1917. Pauline, in presenting the facts about calcium carbide and acetylene, strove to maintain the same straightforward and enthusiastic manner that her late friend and leader had used in the previous editions.

Textile Chemistry Authority and Consumer Advocate

Pauline's trajectory at Penn State began with the teaching of General Chemistry and progressed to her development of the special course in Household Chemistry, which she was still teaching in 1934. In July of 1928, Pauline reported to the convention of the American Home Economics Association in Des Moines that other state colleges were following Penn State's lead in establishing a textile testing laboratory for the use of other state-maintained institutions. Penn State was also the first state association of dry cleaners for the express purpose of training young men for work in association plants. Penn State was preparing to establish a curriculum in textile chemistry in which students would be trained for textile testing work. Pauline pointed out that large department stores had needs in this area, with such positions being very desirable for women. While at the convention, she was reelected national chairman of the textile section of the American Home Economics Association for the second consecutive year. Pauline was also selected to participate on the national committee of the Association that was charged with rewriting the syllabus for college home economics courses.

Pauline instituted the study of Textile Chemistry, building this into a field for graduate work. Tests conducted on household fabrics at Penn State translated into savings for the state in purchasing supplies for public institutions. Harrisburg eventually took over the testing work and a Bureau of Standards was created. Penn State students were

also involved in testing the wearing and washing qualities of silk stockings of various makes, prices, grades, and textures in order to craft standards for that industry.

Pauline became nationally known during the latter half of the 1920s for her research on synthetic textiles. In collaboration with Freda J. Gerwin Winning, assistant professor of education of the Department of Home Economics at New York University, she showed that silk manufacturers weighted their fabrics with chemicals, frequently tin, so that they would feel more like higher quality silk. Lead compounds had also come into use to a disturbing extent. Pauline was adamant that lead weighting should be differentiated from other types because it presented a definite health hazard despite findings to the contrary by research that was subsidized by American holders of lead weighting patents. Silk clothing that was chemically treated tended to fall apart within six months. Pauline called the practice of weighting silk the greatest abuse of a textile fiber that had ever occurred in history. While this silk scandal was taking place, Pauline represented the American silk consumer and advocated for the crafting of industry standards.

Pauline engaged in consumer studies with staff members of home economics departments of other universities and colleges, as well as with Penn State graduate students who were working on advanced degrees in home economics or chemistry with a major in textile chemistry. William Edward Coughlin, reporting on his dissertation study pertaining to silk weighting in the *Journal of Physical Chemistry* (1931), gratefully acknowledged Pauline for suggesting the problem of his study and for giving active assistance throughout the work.

In the spring of 1930, Pauline and Freda Gerwin Winning undertook a study on the style, workmanship, size, and fit of silk dress garments in relation to price. Fifty street-type silk dresses were purchased in New York City at prices ranging from $2.98 to $59.50. Anonymous consumers provided money grants to fund the purchases. The purpose of the study was to determine whether accurate sales information was being provided about ready-made silk garments and the fabrics of which they were made, and whether or not there existed any relationship between price and attributes of the garments. The study revealed that salespersons provided little useful information about the characteristics of the dresses or the best methods of taking care of them. Prices varied greatly for dresses that seemed to be identical or very similar. Except for very high- and very low-priced dresses, price was not a measure for style or workmanship. Dresses from the highest price range were of better style and workmanship, while dresses in the lowest price range were poorer than those in the middle ranges. The fit of dresses improved as the price increased. Measurements of various parts of the dresses varied greatly, revealing the lack of standardization in garment sizes.

If Pauline's collaborative study were to be replicated today, my clothing experiences suggest she would find similar results regarding pricing and sizing, though the price range would be higher overall. Materials would differ. In addition, I would find a label, a rarity in the early 1930s. Pauline indicated in 1934 that the scarcity of informative labeling was not due to a lack of consumer demand for information or to a scarcity of the technical data required to establish worthy, practical consumer standards. While consumers had made both individual and organized efforts to engage

manufacturers and sellers in standardization and correct labeling, their efforts had not had much success. The information rarely went beyond the last seller to the ultimate buyer.

Pauline responded to the assertion of the silk trade that consumers were only interested in the style features of silk fabrics with the results of a study of 100 silk dresses that had been disposed of by women of varying economic status. Out of the 100 dresses, 66 had been thrown out because the fabric was no longer wearable due to splitting, fading, or shrinking; 25 were no longer wearable due to other reasons; 7 were tossed because they were out of style; and 2 were disposed of because of poor fit. The women interviewed for the study were mostly unhappy with silk that had broken and many wanted to be able to recognize a quality piece of silk.

Students under Pauline's guidance conducted and published many studies related to silks in the latter half of the 1920s and throughout the 1930s. The *Journal of Home Economics*, *Rayon and Melliand Textile Monthly*, and *Laundry Age* communicated the work that was taking place at Penn State. Anne Argue D'Olier, working on a senior problem in textile chemistry (1931-32), examined the effect of storage in the dark for varied lengths of time on the breaking strength of weighted and unweighted silks. She found that the losses in strength were little as compared to the losses found by Nellie Myres Roberts, when silk from the same series was exposed to indoor daylight for much shorter time periods. Nellie, a holder of the Textile Standardization Fellowship of the American Home Economics Association (1929-1930), completed her M.S. degree in Home Economics, publishing several papers with Pauline that resulted from her thesis work at Penn State. In addition to studying the effects of light and air on the physical properties of weighted and unweighted silks, Nellie also examined the effect of weighting

on the air permeability of silk, finding that the permeability of any air pressure decreased as the percentage of weighting increased. Winifred Mather Forbes, holder of the Textile Standardization Fellowship in 1928-1929, had also studied the effect of tin-weighting on the strength of silk as part of her work for her M.S. degree in Chemistry. Her findings had significance for the consumer who would be apt to judge the value of a silk by its appearance and weight. In every case she studied, the breaking strength per unit weight of fabric decreased markedly with each increase in tin-weighting.

There was no dearth of research avenues for the students Pauline supervised. Bertha Cohen, in a study she conducted for an undergraduate course in Textile Chemistry, examined the effect of water-washing upon the strength of unweighted silks. Elizabeth Claire Ramsey, as part of her work for an M.S. degree in Textile Chemistry in 1929, researched the effect of dry cleaning and water washing on the strength of unweighted and of tin weighted silk. Research was also conducted by students that had fellowships from the Pennsylvania Association of Dyers and Cleaners. Mary Deck Hale, a 1934-1935 Research Fellow of the Pennsylvania Association of Dyers and Cleaners, undertook a study of the effect of various dry cleaning solvents on unweighted and on tin weighted silks. Charles Rush Phillips, holder of a 1935 research fellowship, investigated breaking strength of weighted silk garments in dry cleaning trials of miscellaneous silks.

The issue of stains. It is the mid-point of the 1930s. Research Professor Pauline Beery Mack and Fred Osterling, Research Fellow of the Pennsylvania Laundryowners Association, are in the lab with several associates. Pauline and Fred know that the primary purposes for using bleaches when washing fabrics are to maintain whiteness in white fabrics and to remove varied stains. The notion that bleaches remove

general soil has been cast aside. On this day in State College, the researchers contemplate cotton fabric strips, each containing 18 squares stitched together. Every square was individually stained before being assembled into strips. Stains were selected from a survey on which ones were most frequently found in the power laundry. Pauline and Fred eye an untreated test strip that sports stains ranging from coffee (with and without cream), tea, iron rust, beer, India ink, grass, blood, iodine, huckleberry, and others, satisfied that the most commonly found stains are sufficiently represented. Their attention turns to some of the representative strips that had been treated with either chlorine bleach or with hydrogen peroxide and then washed once in a regular commercial laundry. Questions abound. What effect does varying the quantity of bleach have on whiteness retention, stain removal, and breaking strength? What about varying the type of bleach? The temperature of the bath? Laboratory trials follow- fifty washes for each varied condition.

In analyzing the results of many laboratory and plant trials with hydrogen peroxide, Pauline and Fred conclude that increasing the hydrogen peroxide bleaching bath above 160° F. results in excessive losses in fabric strength. Their recommendation for laundryowners is to not exceed this temperature. Pauline, Fred, and their associates discuss concentrations of bleaching agents. Results indicate that increasing the concentration of hydrogen peroxide does not yield the level of fabric strength losses as happens with increasing the concentration of chlorine bleach. It is duly noted, however, that economics is a factor. It makes sense to use the lowest concentrations that result in good stain removal and whiteness retention. The group moves on to a discussion of pH and its effect on fabric strength. Pauline and Fred remain after the group disperses. They

have supervised several plant trials of a laundry bleach known as sodium perborate, which has been used extensively in bleaching woolens and silks. Some commercial laundries were also utilizing it as a bleaching agent. Pauline wanted to discuss the laboratory trials taking place at Penn State with Fred.

In the summer of 1936, co-authored articles on their bleaching studies would appear in issues of *Laundry Age*. Pauline and Textile Chemistry students, Helen Naomi Wenger, Rebecca June Mostoller, and Mary Theresa Baer, reported on their research for determining the efficiencies of commercial and household washing procedures in a 1937 bulletin. They concluded that one no longer needed to rely on prejudice or visual examination in order to establish the efficiency of home, institutional, or commercial washing procedures. Exact methods of measuring laundry efficiencies had been developed at Penn State. Commercial methods had been shown to be more efficient than home washing methods, indicating a need for research to improve the efficiencies of common methods of home washing.

Pauline and Harney Stover addressed the issue of the satisfied customer in 1936. They made the connection to certified laundries training their staff to become highly skilled technicians who cooperated with scientists in Penn State's research and testing laboratory for the express purpose of rendering the best possible service to the public. They exhorted sales managers to develop various plans to fit the pocketbooks of the greatest number of people and also challenged sales representatives to be interesting, straightforward, and accurate in presenting the story of laboratory control and laundry performance. Pauline and Harney noted the benefits of taking care of one's customers, as business success depends on repeat sales. It's also prudent to keep in mind Pauline's and

Harney's caveat that a disgruntled former customer is the worst liability a business can have!

Efforts to standardize. By 1934, Associate Professor of Chemistry Dr. Pauline Beery Mack had become an international authority on Textile Chemistry. Pauline had overseen the development of standard soiled test fabrics in the laboratories at Penn State. The amount of soil removed during a cleaning process indicated whether the cleaning method utilized was first class or inferior. As representatives of management and labor came together to formulate codes for many industries, the cleaners and dyers were unique in asking for consumer representation. Pauline assisted in the formulation of the Cleaners and Dyers Code, incorporating a set of standards which allowed the consumer to gauge the quality of the service received. The code was rejected nationally, but accepted by the Pennsylvania Association of Cleaners and Dyers. Pauline was also the technical adviser for the Pennsylvania Laundry Owners Association, which had already been using standards she developed for two years. Members of the association who met the standards received certificates.

Pauline and many other organizations and individuals in the 20th century worked toward the development of consumer standards for textile commodities. One of the earliest efforts came in the early 1900s by the American Home Economics Association. This group worked toward the standardization of textile fabrics and clothing, forming a Textile Standardization Sub-Committee in 1919. In 1972 the Federal Trade Commission brought forth the Care Labeling Rule. This was the first time that manufacturers were required to label their clothing with directions for at least one method of safely cleaning a garment. Manufacturers were allowed to replace text with symbols developed by the

American Society for Testing and Materials (ASTM) in 1997. Consumers can now more easily base their purchasing decisions on the type of care a garment needs. They also have information on how to clean garments so that appearance and performance over time is maintained.

Unceasing efforts. Through her textile research, efforts to improve industry standardization, and promotion of the education of the consumer, Pauline systemically tackled issues. In addition to the prolific publications emerging from the research at Penn State, the work taking place there was also presented to diverse audiences. Pauline was frequently asked to address conventions of laundry owners, drycleaners, textile associations, and women's clubs. From home town to the national stage, she drew attention to Penn State's research in support of consumers and industry. A brief snapshot illustrates the range of her endeavors: In May of 1935, the Pennsylvania Laundryowners Association convened in State College to find out the results of research work. Pauline headed up the committee in charge of the convention. Fred Oesterling was on board to present on the topic of the proper methods to launder woolens. Pauline addressed the topic of digestive enzymes as assisting reagents in laundering starched fabrics. Pauline's mother, Mrs. J. P. Beery, supported her daughter's work as a leading authority in the field of textile chemistry by taking charge of the tea for attendees' wives that was held at one of Pauline's favorite dining places, the Nittany Lion Inn.

Identified by the New York Times as a spokesman for consumer groups, Pauline reported on active consumer educational campaigns at the 16th annual Women's National Exposition of Arts and Industries held in New York City's Grand Central Palace in March 1937. In September 1937 a textile exhibit and lecture by Pauline on *Science in the*

home were part of the entertainment for the 43rd Summer Meeting of the American Mathematical Society held in State College. October of that year found her back in New York at the Hotel Astor for a round-table discussion of the Premium Advertising Association. Once again, Pauline was advocating for the establishment of standards that would guide consumers and also benefit manufacturers. Pauline noted that standards support consumer knowledge of what to expect of an article in certain price ranges while helping the manufacturer shape its product and price it in accordance with public expectations. Consistent in her message, Pauline declared to the assembled group, "We are anxious to see that each article does in its particular price range what is expected of it."

In May of 1940 the National Association of Better Business Bureaus, Inc. addressed the perspectives of businesses and consumers by conducting the Business-Consumer Relations Conference at New York City's Hotel Pennsylvania. Pauline, on hand as the luncheon session speaker, was frank in her remarks. Portraying gullibility as the burden of consumers, Pauline asserted, *"It has been a long uphill struggle to get the facts, but we are getting to the point where business is playing on intelligence rather than gullibility"* (Consumers Advise, 1940, p. 38). Future generations of consumers were represented at this conference as well. Mary Isabelle Pfeiffer, a Penn State student, was one of three female university students who talked about how they used informative or grade labels to guide their purchasing. The girls also stressed that the current labels could be greatly improved through more data. Pauline was not one to shy away from long uphill struggles. Over the course of her lifetime, whether in a lab or on the road with a purpose,

her students, colleagues, husband, and parents would see the consistent threads of her tenaciousness.

A dramatic trial. Today's CSI fans, perceiving the potential benefits of textile expertise in issues dealing with solving and prosecuting crimes, would not be surprised to find Pauline in a courtroom. The Bellefonte courthouse was the site of a dramatic trial in 1940. District Attorney Musser W. Gettig presented some key points in his summation to the jury. First of all, there were Richard Millinder's confessions that he murdered Faye Gates, corroborated by the testimony of several state witnesses. In addition, he had scientific evidence substantiated by Dr. Pauline Beery Mack. Pauline testified at the trial that fibers from Millinder's sweater had been found under the victim's fingernails. In addition, strands of Faye Gates' dress had been identified on Millinder's sweater. Defense Attorney Lewis O. Harvey, noting that the state had mainly circumstantial evidence, asked the jury for an acquittal. The jury came down on the side of confessions and science, finding Richard Millinder guilty of first degree murder with a sentence of life imprisonment. Millinder, according to the *Daily Collegian* on September 16, 1940 (p. 1), took the jury's verdict "like a man."

The Pennsylvania Mass Studies in Human Nutrition

It is the summer of 2008 and the temperature has climbed to 105° F. in Denton, Texas. Three of us enter a room in Pauline's former building on the campus at TWU. Numerous file cabinets contain the records from Pauline's nutrition studies. There is a wealth of data here, begging to be entered into some computer system. It would be an enormous task, as the amount of data defies conception. The massive collection of files in

Texas is a visible reminder that since her start in 1934, Pauline charted new territory with the type and scale of her data collection.

Pauline's work extended far beyond the area of textiles, with the chemistry of human nutrition serving as her major research interest. Concern for bad dietary habits is not just a present-day phenomenon. In the mid 1930s there existed awareness of the need for valid techniques to appraise the nutritional status of humans in order to improve poor dietary practices. Reflecting in 1951 on that era, Pauline wrote to G. L. Haller that work in [nutritional chemistry] during that time was primarily being done with experimental animals. Some isolated work was being done in various places on a technique or so involving the assessment of nutritional status in humans. However, no laboratory had formed an extensive battery of tests to evaluate human physical status as it related to nutrition. Pauline would soon change that situation as her ideas morphed into a longitudinal study of thousands of Pennsylvanians of different ages, economic status, and ethnicity.

Pauline's nutrition studies began to expand when another Pauline arrived on Penn State's campus. Miss A. Pauline Sanders was chair of the Home Economics Department at Seton Hill College. Miss Sanders had modeled her department after Penn State's program, as no other Catholic college had such a department in 1931. Miss Sanders came to Penn State to undertake graduate study, planning to survey the dietary habits of families in her home county. Pauline extended Miss Sander's plan to include the study of the resulting nutritional status of the families. Pauline purchased some equipment with her own money to help launch the studies. In 1935 the Pennsylvania Mass Studies in Human Nutrition were initiated at Penn State to gather information about the dietary

habits and nutritional status of representative residents. This series of studies would use applicable, multiple objective tests, since no single test would be a criterion for nutritional status. In 1936 the Pennsylvania Department of Health began cooperating in the studies and furnished grant funds. A report on the first several years of the studies acknowledged the help of many medical personnel who undertook medical examinations, nutrition testing, and data calculation. Three individuals had helped to prepare the report, one of whom was Pauline's mother, Dora Woodford Beery.

Miss Sanders' study was first in the series, reported on in her 1937 dissertation. Her study involved 100 urban families with a wide range of incomes. Staff members and technical workers followed her work with two major studies. One was a study of the dietary habits and nutritional status of representative Pennsylvania families. This project was supported with federal funds obtained from the Office of Experiment Stations under the Purnell Act. The second study examined the dietary habits and nutritional status of school-age children in Pennsylvania. Penn State, special acts of the Pennsylvania Assembly, donations from interested parties, and grants-in-aid from the Rockefeller Foundation, the Milbank Memorial Fund, and the Pennsylvania Dental Society financed this research.

The magnitude of the work involved in these studies is revealed by a look at just one of these studies, The Pennsylvania Child Nutrition Study. Four communities were involved. Participants came from two cities (~82,000 and ~125,000 inhabitants), a college town (~7,000 inhabitants), and a rural community with one consolidated and two one-room country schools. Most of the 1492 children in the study attended fifth grade. Consent slips were sent home, with an occasional trip by a visiting nurse to the home to

further explain the study. Each child in the nutrition study was given a medical examination and a Mantou test (tuberculin skin test). If the Mantou test was positive, chest roentgenograms were taken. A medical examiner advised on the exclusion or inclusion of children in the study. Some of the children were given a basal metabolism test. In addition to a range of tests and examinations, diet records were obtained. At the conclusion of the study, visiting nurses took reports of the results for each child to the home to explain the findings and their likely significance to an adult in the family. From this data-rich study, family income differences were revealed in the percentages of individuals who were underweight, skeletal status, hemoglobin, and response to the biophotometer test. Of the four communities in this study, children from the two industrial communities were much lower in skeletal mineralization than those from the college town community. It was noted that one of the industrial communities had been financially depressed for several years. Children from this community were somewhat lower in skeletal maturity than children from the other three communities, which were similar to each other in this regard. Children from this economically depressed community were also found to be exceptionally low in hemoglobin values, in contrast with those from communities in better economic circumstances. Test results from urban individuals were more affected by income and education than results from farm families.

Prenatal implications. One of the nutrition studies conducted at Penn State involved X-raying the left arms and left legs of approximately 400 babies born in nearby Philipsburg during the study timeframe. Arm and leg bones, X-rayed within 48 hours of birth, were rated according to maturity and mineralization standards. Pauline, Portia Bricker Harvey, and Alice Jones Beakley found differences that may have been

attributable in part to somewhat better diets available during spring and summer months and also to the increased amount of sunlight present during that time period. In her October 4, 1940 press release, Pauline highlighted the findings that average bone ratings became successively poorer from October and November to June and July and then began averaging progressively better. This prompted the *Daily Collegian* headline of November 1 (p. 8): *"Born in the Fall? You're Lucky!"* An additional finding of the study indicated that mothers in their early and middle twenties were more likely to have children with better initial bone structure than mothers of other ages. Dr. Mack, the consummate purveyor of information for the general public, emphasized that "the study points clearly to the fact that too little education on diet during pregnancy is being given during the present time." Reiterating the value of education, Pauline pointed out that "More attention should be given to this subject in the schools and in adult classes. In this and other studies, it has been found that education is as important a factor as purchasing power in the wise selection of foods."

School lunches. Shaking my head, I ponder the laments of a kindergarten teacher. One of our parents insisted on delivering pizza each day for the child, as he wasn't about to eat anything else. Scanning the cafeteria, I noted the diversity in nutritional value of lunches brought from home- from peanut butter and jelly to mostly chips, cookies, and cakes. Some children had fruit and vegetables. I thought about the struggle to provide a school lunch that was rich in nutrition and affordable. Availability was one issue, encouraging good eating habits another. I leaned down and suggested to a little one that he put his dessert aside and eat his sandwich first. It is not surprising to find that the vast

nutritional studies taking place at Penn State had relevance for school lunch programs. Some issues have long-standing roots!

Succinctly reporting on the findings of a four-year study started in 1936, the *Daily Collegian* (1940, October 12, p. 3) suggested that if you desired your child to be physically and mentally healthy, you needed to examine the contents of the child's lunch box or what he is eating at school to insure that the food contained sufficient proteins, minerals, and vitamins. Correlations of the average intake of energy, protein, minerals, and vitamins for children of families of varying income levels deriving from the studies provided a new focus on the appropriate content of school lunches for children in varied income levels. In the same article, Dr. John J. Shaw, State Secretary of Health, commented on the advances made in determining proper nutrition for school children: "Children's diets may now be planned on a scientific basis, just as one draws blueprints for the building of a house." Pauline and her colleagues had quantified the ideal lunch.

Noting the general interest in possibly improving the nutritional status of grade-school children by a mid-day feeding at school, a report on the "school lunch" study described the series of nutrition tests given to 225 children who represented a wide range of family income levels. Income levels ranged from Class A-1, $10,000 or above, through C-3, $1000-$1,499, to Class D, below $1,000 excluding families on direct relief, and Class E, income of families on direct relief alone. Educational levels were rated similarly- Class A designated a family where all adults were college graduates, while Class E indicated that no family member was a high school graduate. There was also an extensive 100-point system for grading a home's physical characteristics, giving credit to home features that were perceived to influence the general well-being of family

members. Points were given in such categories as size, furniture, interior cleanliness, central heating, convenient cooking equipment, satisfactory refrigerator, and provision for rest. Even the exterior condition of the house and the presence of grass and flowers were rated. Pauline and her colleagues calculated the average intakes of specific nutrients for breakfast and dinner combined, compared that with the Bureau of Home Economics Standards for the nutrients, with the children classified by income groups (as determined by family cash income). Then they calculated the amount of each nutrient that would be needed to bring each income group up to the current standard, designating this as the ideal lunch. Their findings emphasized the need for protein, calcium, phosphorus, iron and several vitamins, while minimizing foods that primarily provide only energy (i.e. calories).

Pauline's research group was cognizant that most school organizations provided lunches that were in direct opposition to the findings of their study due to limited school budgets. The researchers suggested that careful planning would offer students the nutrients most likely to be inadequate from their home diets for little cost. Options for practical application of their findings were included in the study report. The *Ladies' Home Journal* (LHJ) advocated for a school lunch program in an article provocatively entitled "Has Your Child Half a Hog's Chance?" in October 1944. LHJ asserted that the nation's livestock was better taken care of than our primary resource, boys and girls. A basis for this allegation was the fact that the first federal appropriation for hot school lunches occurred in 1943, while government appropriations had already supported a feeding program to improve U.S. livestock for 60 years. In making the case for the hot-lunch program, LHJ presented Pauline's research findings, illustrating the importance of

nutrition with the contrasting stories of two youth who were part of the Pennsylvania Mass Nutrition studies, Tony and Judith. Directions on how to apply to the War Food Administration to start a school lunch program in one's community were detailed. LHJ reprinted 7,000,000 copies of the article.

The nutritional studies conducted by Pauline, her colleagues, and her students would be of such magnitude that their findings would have lifespan implications from cradle to grave. In later years, the significance of Pauline's work would extend to outer space.

X-ray Pioneer

A major component of the Pennsylvania Mass Studies in Human Nutrition involved the pioneering use of X-rays to monitor changes in the bones of living subjects, a methodology invented by Pauline. She and her colleagues rebuilt a Moll micro-photometer manufactured in Belgium with help from Ernest Axman, the instructor in electrical engineering who also assisted Pauline with her doctoral research. The modified instrument was then utilized to make tracings of roentgenograms of bones adjacent to an ivory step-wedge. (Ivory was later supplanted by a special aluminum alloy constant-slope wedge that had the same X-ray absorbency as bone calcium hydroxyapatite. Alcoa Aluminum in Pittsburgh prepared this alloy.) The researchers used a planimeter to measure the area between a tracing and a base or zero line. They recorded the area per unit length of base line in comparison with the area between the tracing of a density ladder (i.e. wedge) and the same length of base line. The traced areas represented absorbency by the bone part and by the wedge, which were then compared. In this manner, densities of similar sections of specific bones of two or more individuals were

able to be compared. In this device and the next three versions, the end product was the trace of the desired section of bone and of the accompanying standard of reference. The planimeter was operated by hand. Necessary corrections on the bone trace area were accomplished according to a mathematical formula. By 1949 a fifth model would be in use at the Ellen H. Richards Institute. Model Number 5 corrected for ladder deviations. It could also achieve planimetering electronically and retrace both bone and standard reference traces ideally.

The X-ray machines themselves were standard portable units, of which they had two. One was normally kept in State College and the other was located at the Children's Hospital in Philadelphia. One day the unit in the Textile Chemistry Building failed. George Vose recalled flying to Philadelphia to get the unit there while the tests in State College were put on hold. The X-ray machines were transported to testing sites in other areas of the state as needed. George noted that while the machines were portable, transportable would be a better term- they were heavy!

Bone research was initially scoffed at by many people. The common mindset was, "*What is there to learn about bone?"* One of Dr. Mack's greatest achievements was changing the lay descriptive perspective of bone from "a solid inert structure" to "a dynamic tissue."

Transcendent Relationships

Pauline's relationships at Penn State with students and staff were complex, often extending beyond typical teacher-student or employer-employee boundaries. Some of these relationships would also end up crossing geographical boundaries, as a nucleus of

Pauline's colleagues would end up following her to Texas. Pauline expected much of others and gave much as well, mirroring her relationship with her parents.

From student to secretary. Jean Sherrill was engrossed in the news on the evening of January 29, 2009. Governor Rod Blagojevich had just become the first Illinois governor to be removed from office, notable in a state with a lengthy and plentiful history of graft. Now 90 years of age, Jean last travelled back to State College two years earlier. There is something about Pennsylvania after all these years that still makes it feel like home. Jean, if you recall, was one of Pauline's undergraduate chemistry students as a home economics major. Her parents had been instrumental in the choice of this major, as economic times in the last half of the 1930s were difficult and home economics seemed to be a good field for women. Jean was not too enthusiastic with home economics, but one was not as likely to change majors in those days. She did, however, minor in business. Hoping to stay in State College following her 1939 graduation, Jean filled out an application in the campus employment office. When nothing turned up, she went to New York to the Katherine Gibbs School to take the school's special one-year secretarial course for college graduates. Jean's boyfriend and future husband still had another two years to go to complete his undergraduate degree in chemical engineering at Penn State.

Fortunately for Jean and Joe, Pauline ended up needing a secretary. In Pauline's impetuous way, she called Jean and asked if she would be interested. Soon after, Pauline was in New York on a business trip (she was always flitting off to some place) and interviewed Jean at her hotel. They reached an agreement that Jean would come to work as her secretary in May 1940 when she finished her course at Katherine Gibbs. Jean was delighted and subsequently returned to State College to work for Pauline at a salary of

$78 a month. In 1942 Jean married Joe, who was now in graduate school. She continued to work full time for Dr. Pauline until she had her first child in December 1943. After that, she worked part time.

Jean found her new boss to be unusual. Jean and others used to joke that Pauline wore the same dress every day, as she wasn't involved in trying to make herself attractive. Dr. Pauline was somewhat feminine, but she was in charge. This self-confident woman liked being in a mostly male environment. Dr. Pauline, not one to feel she was at a disadvantage, was very outgoing and wasn't afraid of anyone. Dr. Pauline was driven to accomplish things in both textiles and nutrition. In a way, Jean pondered, Dr. Pauline was a friend, and in a way, a boss. You worked hard for her. However, she was always there when you needed her. Jean pointed out that Dr. Pauline would get some of her staff people to do things beyond the job. They sometimes felt put upon, but most did these unusual things cheerfully: *The skies are gray this holiday season. Dr. Pauline has had some of Warren's engravings made into cards. Her holiday newsletter is ready to be attached to them. Given Pauline's extensive list of recipients, graduate students and staff members are hustling to address the cards. It is a whole department effort!*

Dr. Pauline's relationships with students mirrored her relationships with staff members. She was a hard taskmaster, but it was a two-way street. She had a personal interest in and concern for her students, and would go far past the second mile for them, especially graduate students. Dr. Pauline's dedication to equal rights was evident. She had a great commitment to African American students. Jean discussed a tour of the South during which Dr. Pauline and Warren visited several traditional black colleges. The *Daily Collegian* reported on the Macks' visits to Arkansas State Teachers College and the

College of the Ozarks in January 1944 (On nutrition). Dr. Pauline and Warren, as representatives of the Association of American Colleges, presented a series of lectures on the dynamics of human nutrition at the colleges. Some students decided to further their education at Penn State. The 6-8 black students that Jean remembers were teachers in the South who came to Penn State during the summers to get their degrees. They had to stay for one semester, as well, to meet residency requirements. It was a big struggle in getting the requirements and the dissertations done. Dr. Pauline was anxious to help these students advance their degrees. Jean still remembers how very natural Dr. Pauline was with the students as she supported their success. Over the course of her lifetime, Dr. Pauline evidenced great interest and support for individuals in less than equitable circumstances, whether that was women, minorities, consumers, or children with socio-economic challenges that put them at nutritional risk.

Jean's husband Joe finished his Master's degree in Chemical Engineering in 1947. Dr. Pauline offered him a staff position in textile chemistry research while he worked on his Ph.D. Joe took Dr. Pauline in stride, as they were a good match. They got along very well and Joe admired her. Dr. Pauline returned the sentiment, as she was fond of him. The Sherrills' story continued when Dr. Pauline, the renowned Pennsylvania researcher, became a Texas woman larger than life. In the meantime, Jean's presence in this story was facilitated by George Vose, who was a long-term colleague and friend of Dr. Pauline. George remains on Jean's Christmas card list to this day.

Pauline's oldest friend. Connecting with the 86-year-old referred to by Pauline as her oldest friend is not as easy as it sounds, especially if that person is George Vose. George is one of the oldest surviving individuals who knew Pauline in both the

Pennsylvania and Texas phases of her career, though at age 90 Jean Sherrill edges him out! At first I thought my difficulties in reaching George by telephone after receiving his signed consent form were due to his travels between two residences. After five weeks, my concern was at an all-time high, with good reason as I discovered. My phone finally rang on a Friday evening and I was ecstatic to see George's number on the Caller ID. Turns out that George, a former pilot, had attended a pilots' convention, fallen, fractured two cervical vertebrae, and was then flown to a hospital in Memphis. His voice reflected the pain he still had, though his words were of concern for my study! Declaring that Dr. Mack had both friends and enemies, he paused. "I grew up with her," George reminisced. I was left to ponder the nature of his relationship with Dr. Mack until George further recovered from his injuries. Finally connecting through telephone and email, George had much to say about growing up with Dr. Mack.

It was purely accidental that George Vose met Dr. Pauline Beery Mack. World War II had just started. Civilian pilots were grounded on the east and west coasts for 150 miles inland. George moved to Bellefonte, Pennsylvania to learn how to fly. The National Youth Administration was offering courses at the local airport. George took a welding course, which brought with it the requirement that he sign up with the Pennsylvania Employment Commission. Imagine George's surprise when he received a notice to go to State College for an interview! Dr. Mack's group was looking for someone with X-ray experience. It seems that George had worked in a hospital following high school and had learned how to take X-rays. He had driven doctors to homes and could take a portable X-ray to someone's house. George arrived on campus for the interview five minutes before they were ready to close. He told a man that he was looking for the Textile Chemistry

Building. He replied that George must be looking for Dr. Mack and provided directions. Jean Sherrill, as Dr. Mack's secretary, was George's first contact with Dr. Mack's group. She guided George to his interview with Louis Shetler. George was selected for a job that paid $0.35 an hour, starting at 6:00 p.m. for eight hours. The hours fit George just fine since he was taking flying lessons during the day.

George didn't meet Dr. Mack right away. One day she recognized him by his Maine accent, saying it was beautiful. He was 18 years old at the time and unaware that he would be colleagues and friends with Dr. Mack until the end. George was overwhelmed by Dr. Mack when he was young. Dr. Mack would joke that she was old enough to be George's mother, eventually changing that to grandmother. He would find Dr. Mack to be one who takes command. She knew her goals and strove to get them. George made significant contributions to Dr. Mack's efforts through his work and friendship.

In the early 1940s the equipment in use was crude. George would stay up all night and develop X-rays. Nutrition, George thought, was Dr. Mack's first interest, engendering jealousy on the part of the dry cleaning people. George pointed out that human consent for nutrition studies was not required in those days, you just did it. George ended up writing a letter saying he was leaving Penn State. In October 1943, one day after receiving his flight instructor certificate, George went off to become involved in the war. He traveled by bus to Westfield, Massachusetts, where he began instructing Army Air Force cadets at Barnes Field. During the time he trained flight cadets in Westfield, Massachusetts, George corresponded with Dr. Mack. With the slowdown of Army flight training, George entered AAF active duty in 1944 in the 4th Air Force. With

others, he trained fixed gunnery to early jet pilots preparing for the invasion of Japan. George was thankful this never happened. A year into his AAF work, in the wee hours, someone walked through the barracks shouting, “Wake up! The war’s over!”

After World War II, Dr. Mack wanted him to return to Penn State. In March 1946 George returned to Penn State to resume his work with her. However, aviation was still fresh in his blood and he desired to return to California to take up commercial flying. Dr. Mack arranged for George to have a one-year leave of absence from Penn State. At the end of his leave, early in 1947, he returned to Penn State. George did not have a degree when he first started working for Dr. Mack. After World War II, she encouraged him to get his degree. George thought that four years of college would be similar to prison, though he ended up earning a B.A. in Science in 1951 through the College of Liberal Arts, taking mostly astronomy and earth science courses. Soon after, he received an offer from Dr. Mack and George would be packing again.

Ellen H. Richards Institute

In 1941, Pennsylvania’s Representative Sarrof put forth a bill to the House Appropriations Committee to give the Department of Health $20,000.00 to be used at Penn State for child nutritional research under Pauline’s direction. The *Daily Collegian* pointed out that this and other bills, if they passed both houses, would end up with red-haired, economy-minded Governor Arthur James, who had the liberty to chop them down, though he couldn’t increase them. The *Collegian* noted the Governor’s adamant position that year in not increasing the college budget, in spite of the new buildings and increasing enrollment. Fortunately for Pauline, she was adept at bringing in funds from a multitude of sources. In fact, Pauline’s work in both textile chemistry and nutrition

chemistry had drawn so many industrial grants and projects that Penn State moved to consolidate the projects under one umbrella. At the January 25, 1941 meeting, the Board of Trustees established the Ellen H. Richards Institute. The Institute's work would involve many organizations over time. Pennsylvania's Department of Health worked cooperatively with the researchers at the Institute. Some of the Pennsylvania Mass Nutrition Studies would end up being conducted in Philadelphia in collaboration with the Vitamin Research Laboratory, Children's Hospital of Philadelphia, School of Medicine, University of Pennsylvania, and under the sponsorship of the Philadelphia Child Health Society.

Pauline worked on a journal article about her new Institute, contemplating the history of her predecessor in the field. Ellen Richards had studied chemistry at Vassar, earning a B.S. in 1870. She then managed to become the first woman to attend and graduate from MIT, accepted as a special student to prevent a precedent from being set for the general admission of women. In 1873 she earned both a B.S. in Chemistry from MIT and an M.S. degree from Vassar. Throughout her career, she trained many young engineers to work in the field of sanitary chemistry. Richards also served as an inspiration for numerous young women to study science from the perspectives of their potential professions and their roles as future leaders in the home. Pauline noted that Ellen Richards had served as the first president of the American Home Economics Association, an organization that reflected both Ellen's philosophy and that of the Ellen H. Richards Institute (Mack, 1941, p. 232): "to improve the conditions of living in the home, the institutional household, and the community," partly by "encouraging and aiding investigations in research in universities and in the state and federal governments."

While Richards was not directly connected to Pennsylvania, Pauline reflected upon the transcendence of her work. Dr. Pauline Beery Mack hoped that her Institute would be of sufficiently broad interest to people of all socioeconomic levels across the country that it would be worthy of the pioneering chemist and household scientist whose name it bore.

Food, clothing, and shelter, the fundamental underpinnings of one's standard of living, formed the Institute's research core. The Ellen H. Richards Institute drew together many projects that were being handled by the departments of chemistry and home economics and in the Agricultural Experiment Station. Research groups in textile, nutrition, and household chemistry were now housed together. They came under the direction of the Institute's founder, Dr. Pauline Beery Mack, who had resigned as the Director of Home Economics Research to head the Institute. Penn State's human nutrition studies, research in textiles, textile chemistry, and detergency, and research in materials and equipment used in housing were under Pauline's bailiwick.

When looking through a stack of Pauline's papers that had been removed from her Texas office some time after Pauline's death many decades later, I came upon a picture of Ellen Richards. Sitting at that table in Texas, looking at that picture, I somehow knew it was of Ellen before checking it out. Pauline's work at the Ellen H. Richards Institute was a tribute to its pioneers- the woman it was named for and the woman who was its founder. It is no wonder that Pauline kept this reminder.

Wartime Efforts

Following the December 1941 attack on Pearl Harbor, the United States was fully involved in World War II. Engagement in the war engendered varied responses at home. Pauline and a staff of over 60 scientists, nutritionists, and others were engrossed in

various facets of the Pennsylvania Mass Studies in Human Nutrition. War accelerated the pace and urgency of these studies. A. C. Marts, Executive Director of Pennsylvania's State Council of Defense, eloquently noted, "One of the most gratifying aspects of the war effort is the manner in which the public schools, colleges, and universities have adapted their programs to the many needs of the present emergency" (Nutrition Subcommittee, 1942, Preface). In this instance, Marts was addressing, in particular, the planting of school Victory Gardens intended to present products for possible civilian use and for improving school lunch nutritional value. Devoting her efforts to this noble endeavor, Pauline was intrigued enough by notice of a more unusual one that she kept it for over three decades. *Mayhem in Medford* (1942, p. 78), a *Time* article kept by Pauline in her Texas office, may have caught her eye because it involved Medford, Oregon, home to her cousin. Leonard Mayfield, Medford's high school principal, was appalled upon recognizing that the 350 male students in his school had not engaged in any fist fights in a year. Since his students might soon be called upon to kill other boys, Medford High's physical education class was retooled to become a personal combat course, or as Mayfield put it, gang fighting. Students, warned to expect bloody noses and black eyes, were taught how to creep, crawl, break arms, kill with bayonets and knives, and so forth. The encircled article on the page tucked away by Pauline is juxtaposed to one entitled *Terror Continues*. This article described an assault by an angry mother on a timid female fifth-grade teacher in a Brooklyn classroom, a day after several groups had requested police protection from violent students!

Amidst the irony, challenges, diverse perspectives, and sacrifices of the times, Pauline and her husband united in the intersection of their expertise in nutrition and

horticulture to support improved nutrition of civilians in this time of war. As noted by the Nutrition Sub-Committee of the Advisory Victory Garden Committee, Pennsylvania State Council of Defense (1942, p. 3), the exigencies of wartime demanded physical strength at home and on the battlefront: “No halfway measures will suffice in these times, no haphazard attention to the thing upon which we depend for strength- namely, the proper food.” As home to the long-standing Pennsylvania Mass Studies in Human Nutrition, Penn State and its researchers were well-suited to address helping people improve their nutritional intake during this time of emergency.

Dr. Warren Mack served as the Executive Secretary of the State Victory Garden Committee, while Dr. Pauline Beery Mack took on the role of Chairman of the Sub-Committee on Nutrition. Warren, Pauline, and their colleagues mounted an impressive effort to support the objectives of the Victory Garden program: (a) to improve national health, morale, and efficiency by increasing home production of fruits and vegetables; (b) increase consumption of fruits and vegetables; (c) conservation of home garden products; and (d) home preservation of purchased fruits and vegetables. Publications addressing the conservation of Victory Garden products incorporated the wealth of information gleaned in eight years of the Pennsylvania Mass Studies in Human Nutrition. Readers would learn what nutrients needed to be emphasized, which vegetables contributed specific nutrients, methods for conserving fruits and vegetables, and where and how to store them. The issuing of gardening pamphlets by Penn State was hailed by State Secretary of Agriculture John H. Light as a key point in Pennsylvania’s Victory Garden Program. Speaking at a conference in Harrisburg, Light referred to the failed gardens and waste during the last war, as little information was available to guide those

who started gardens (College assists, 1942). Warren and Pauline both spoke at this January meeting of the Victory Garden Program in Harrisburg, with Warren distributing the gardening pamphlets. The following month, a Victory Garden class would commence on the Penn State campus. Dr. George R. Green, head of the department of nature education, and Warren, who was head of the department of horticulture, helped plan the six-week course of training for students, faculty, and townspeople in methods of scientific vegetable gardening for defense. Warren, Pauline, and many others would ensure that the lack of information during World War I would not be repeated in World War II.

In one of their publications, co-authors Pauline and Warren addressed the need in wartime for a methodology other than canning to conserve fruits and vegetables. Pauline and Warren acknowledged the ability of their great-grandmothers in setting a good table without cold storage and other benefits. However, those great-grandmothers were not cognizant of vitamins and enzymes. Though vegetable driers and the steaming methodology detailed by Pauline and Warren were used by a few great-grandmothers, they were not aware of the nutritional rationale for their practices. Modern inventiveness, the Macks noted, brought together the economical aspects of storage space and cost of great-grandmother's method with the conservation of vitamins. Directions, diagrams, and photographs of an inexpensive home evaporator, built by Warren and Pauline, rounded out the information presented. In *Home Dehydration and Wartime Conservation of Fruits and Vegetables*, Pauline and Warren thoroughly addressed the technicalities and science of the what, the why, and the how in a style that is conversational and down-to-earth:

"… the sun, though a liberal creator of vitamins in growing plants, is an Indian giver if harvested plant products are spread to dry under its rays" (1942, p. 1).

Warren and Pauline also reached the public through the popular press. Their article on the health value of apples as a source of vitamins and toxin absorbent appeared in the *Everybody's Weekly* section of the *Philadelphia Inquirer* on November 22, 1942. The Victory Garden Program in many places across the United States was encouraging people to eat more apples, particularly those grown near home to reduce transportation demands during wartime. In addressing the significant contributions of apples to dietary needs, Pauline and Warren advised that an apple a day would probably help to make visits to one's doctor a rarity. Once again, the Macks brought science to the public, this time in delineating how an apple a day fights disease. Who knew the value of pectin in contributing to intestinal health? Part science lesson, part geography lesson, and part history lesson, the facts pour forth in an entertaining manner. No wonder that George Washington required his tenant farmers to plant apple trees. Warren and Pauline made a compelling case for consuming this fruit that predates civilized man.

Of course, one should not forget Pauline's other area of expertise. Five hundred merchants and retail buyers showed up at a Philadelphia Consumer-Retailer victory forum at the Benjamin Franklin Hotel on March 26, 1942. The *Philadelphia Inquirer* published a photo the following day of Dr. Pauline Beery Mack. Pauline and Charles L. Simon, secretary of the Industrial By-Products and Research Corporation, were shown examining a coat constructed of war-time substitutes. Merchants were cautioned to discourage hasty buying and subsequent runaway prices. The war affected both the quality and quantity of clothing and fabrics available to civilians. Few staple

clothing fabrics of prewar quality were manufactured for consumers. Some highly used materials were essentially no longer available to nonmilitary consumers. Several institutions in the country, including the Ellen H. Richards Institute at Penn State under the direction of Pauline, conducted a study that showed how essential fabrics were down-graded during the war. The study demonstrated the need for minimum specifications for staple fabrics. By the end of the war, Penn State had engaged in almost a quarter century of research in textile chemistry. Studies pertaining to textile durability and methodologies of refreshing textile fabrics (dry cleaning and laundering) became even more active. Pennsylvania's post-war prosperity would depend in part on its great textile industry.

Cereal and Football from a Different Vantage Point

Snap, crackle, pop! I've eaten a lot of cereal in my time, Rice Krispies, Raisin Bran, and my all-time favorite, Cheerios. Never once did I consider this as an act of civic duty. My perspective has shifted as I pondered the words of Pennsylvania's Governor Edward Martin crafted in 1944 (Mack, Urbach, Stewart, & Dodds, Preface):

> As a war and post-war measure, civilians are urged to improve their dietary habits in every possible respect, so that physical well-being of the highest order will result… A good breakfast is inexpensive, and every person can help himself and his country by not skipping this meal, and by selecting its contents intelligently.

Martin was basing his remarks on data coming out of the Pennsylvania Mass Nutrition studies taking place at the Ellen H. Richards Institute. Pauline and her colleagues analyzed the dietary and nutritional data of 5,000 subjects in a study of their breakfast habits, particularly the consumption of cereal. The study covered 32,784 days and involved both urban and rural populations across a wide range of income. The

researchers' findings revealed the significance of breakfast as the first meal of the day. Liberal consumers of whole grain cereal were superior in the degree to which they met dietary recommendations and in some of the nutrition tests. The extent attributable to cereal was not ascertained. Marion Margery Scranton, Commander, War Services, Pennsylvania State Council of Defense, exhorted teachers and other community leaders to spearhead an EAT BREAKFAST campaign as a methodology of assisting war workers and other civilians to give more thought to their personal dietary habits. The work of Pauline and her colleagues provided the largest amount of objective data available to date on the relationship of breakfast habits to dietary adequacy. Governor Martin's request has renewed relevance 65 years later in the world's difficult economic times.

Wartime football. It was Super Bowl XLIII weekend. I was wearing my Pittsburgh Steelers shirt in hopes of a home-state win, though I confess to a soft spot for the Arizona Cardinals. Football hadn't been kind to Pennsylvania so far in 2009: #8 Penn State had already lost the New Year's Day Rose Bowl game to #5 USC. Fortunately for Pennsylvania's football fans, the Steelers prevailed. Gnashing of teeth over football is nothing new, particularly at Penn State. While Penn State researchers continued to support the country's wartime needs, Penn State's Alumni Association lamented the effect of war on football in their September 20, 1943 Football Letter to members: "Wartime football is not the same football we've been writing about these last five years; it has not assumed its usually important place on this busy campus."

Having attended recent football games at Penn State and serving as mother, wife, and not-distant-enough acquaintance to some extremely ardent Penn State football fans, I shouldn't have been surprised to find this memento in Pauline's Texas papers. I have no

idea what her perspective was over the controversies detailed within the alumni letter regarding football's proper place in wartime. Perhaps she would have been swayed by the physical value and morale boosting extolled by supporters. In any case, Army and Navy were in disagreement. Army was against having trainees participate in football, while Navy felt that if grades were satisfactory, then football could serve as a helpful adjunct to training for war. Alumni had differing opinions on whether football was appropriate during the times. Ridge Riley, author of the newsletter, discussed the struggles in putting together a team, especially considering that half or more of the servicemen on the squad would depart by midseason for active duty. Riley noted it would be a novel and interesting season. Penn State football seasons usually are.

Joe Paterno wasn't coach yet, but he would become an assistant coach seven years later in 1950. Penn State students, clamoring for a *big time coach for a big time college*, were pleased when Brown University coach Rip Engle was hired. Paterno, Engle's assistant at Brown, came with him to Penn State. George Vose, before moving to Texas, often shared the lunch counter at Cook's Restaurant across from the Textile Chemistry Building with Rip and Joe. Rip and Joe would be engaged in football talk, but greeted George with polite nods and a "hi." Dr. Mack and Warren liked football and Rip Engle met with their approval. Returning from a vacation in Mexico, the Macks stopped in Dallas to see the SMU-Penn State Cotton Bowl. When the score ended up in a 13-13 tie, Dr. Mack said the referees were "biased in the wrong direction."

Coming to the End of an Era

The seven-year period from 1946 through 1952 filled Pauline's life with numerous professional accomplishments and accolades, personal joyous milestones, the

deepest personal losses, and her most significant lifetime transition. Studies continued to pour out of the Ellen H. Richards Institute in collaboration with others. A nutritional study of children in orphanages was partly funded by a grant from the Sugar Research Foundation. Westinghouse Electric Corporation was a partner in a year-long nutrition study of 64 families. The National Livestock and Meat Board provided a $10,000.00 grant to study the value of meat for individuals 50 years of age or older. Pauline's graduate students were busily engaged in research. M. Virginia Jones addressed a problem presented by Pauline for her doctoral research, studying artificial perspiration applied by a variety of methods to rayon fabrics. Pauline provided the means to conduct the study and gave advice and assistance during its execution.

During July 1948, Pauline addressed 115 school teachers who were attending the Rural Health Education Workshop at Penn State. She presented a program on rural nutritional deficiencies. The attending teachers saw the use of the biophotometer, a machine used in determining what vitamins are insufficient through the speed of eye adjustment. Teachers also learned about anthropometric tests that measured body development.

Among the prolific publications during this time was one on the quantitative evaluation of bone density coauthored by Pauline, Walter Brown, and Hughes Trapp. Walter presented a paper on the bone density computing machine at the 1949 National Electronics Conference. In November 1949 Reader's Digest published an article by Lois Mattox Miller. "Well Fed- But Ill Nourished" quoted Pauline and reported her research findings regarding the poorly balanced meals that were common in American households. Following the report on Pauline's work, Reader's Digest received 300,000

letters written in 17 languages. Pauline dictated responses to 25,000 of them! It was a busy and productive time for Pauline and the Penn State researchers.

Professional outreach and personal loss. On December 6, 1946 the Penn State Board of Trustee's Executive Committee increased Pauline's salary to $5,700.00 a year. Still director of the Ellen H. Richards Institute, Pauline was also serving as national president of the chemistry honor society, Iota Sigma Pi. Pauline and Warren went on a western tour, she to visit chapters of the society and he to meet with horticulturists. In addition to addressing the society chapters, Pauline also spoke to students in chemistry, nutrition, and home economics, and met with leading educators and research men in these fields. Their itinerary was extensive, including universities and colleges in Kansas, Minnesota, Iowa, Colorado, Wyoming, Oklahoma, California, and Texas. In Texas, the Macks were scheduled to visit the University of Texas and Texas College for Women. Their tour was interrupted in Austin, Texas, due to illness of Dora Woodford Beery, Pauline's mother. On December 31, 1946, Pauline's mother died in Oswego, Kansas, the town her family helped found. Cause of death was a cerebral hemorrhage complicated by pneumonia. Dora had been visiting her two sisters, Tina Woodford Laws and Nina Woodford, when she became ill on December 14. The home she had been visiting still had a wing built by Harry Lee Woodford, her father, in 1867. With the loss of her father only two years earlier and no siblings or children, Warren was now the last of Pauline's first degree relatives.

The Thursday evening of November 6, 1947 was quite hectic at 245 E. Hamilton Avenue in State College. Pauline, as national president of Iota Sigma Pi (ISP), was hosting a reorganization meeting for the local fraternity. Her friend, Associate Professor

of Chemistry Dr. Mary Willard, was serving as faculty advisor for the group. This particularly important meeting of the women's chemical honorary was scheduled to get underway at 7:30 p.m. Corresponding secretary Annette Lanning had publicized the objectives of the gathering that she termed *suggestion social*. Members would have an opportunity at the meeting to recommend guest speakers for programs that would take place during the current semester. They would also offer input on the Curie Lecture, which was the organization's annual spring event. The group would continue to meet regularly on the first Thursday of each month. On December 5, 1948, the fraternity met at the home of Mrs. Arthur Rose. Pauline was guest of honor at this tea, given in honor of her retiring from the national presidency of ISP. Mary Willard, along with Mrs. T. S. Oakwood, poured the tea.

Figure 5. Home at 245 E. Hamilton Ave., State College, PA. Photo by author, 2008.

A valuable connection. Harry B. Henderson Jr., noted for his books on the history of African American art coauthored with Romare Bearden, studied with Pauline at Penn State prior to graduating in 1936. Harry's career included stints with the United Press wire service, *The Centre Daily Times*, and *The Altoona Tribune*. Turning to freelance writing, his work was published in *Collier's*, *Harper's*, *Reader's Digest*, *Look*, and other national general interest magazines. Also a science writer, Harry brought diet studies and wonder drugs to public attention. This was not always an easy task. Harry desired to

write a science story about the physiological hunger studies conducted by A. J. Carlson, American Association for the Advancement of Science president. Carlson, responding to Harry's request for an interview, asked why Harry thought he could interview him. Harry found that talking about his interest in Carlson's work was useless. Persevering, he finally succeeded in getting his foot in the door when he mentioned Pauline. *Coronet* published Harry's science story in its December 1948 issue.

Some punkins- both. Thomas Desmond, president of the select group Phi Beta Kappa Associates, formally announced the election of Pauline Beery Mack and Warren Mack as 2 of 41 new members on September 9, 1948. Membership in this group, limited to 200, was then closed for an indefinite amount of time. Pauline was a Phi Beta Kappa from the University of Missouri, while Warren was a Phi Beta Kappa from Lafayette College. In referring to the Macks as *some punkins*, the *Centre Daily Times* explained that the back of the Phi Beta Kappa keys contained the intertwined letters SP. The derivation of the letters was lost from early times, leading to a popular vulgar explanation that they represented *Some Punkins*. Penn State's Department of Public Information provided local news media with a press release about the honors. In it, Warren was referred to as Dr. Warren B. Mack. Sixteen years after earning her Penn State doctorate, Pauline was referenced as Mrs. Mack.

This was not the only similar honor to be bestowed upon the Macks. Warren received an honorary degree of doctor of science from Lafayette College in 1946. General Dwight D. Eisenhower, on the same program, delivered a Founders' Day address and received an honorary doctor of laws degree. In 1950 Pauline was bestowed with

honorary Sc.D. degrees from Moravian College for Women and Western College for Women.

A jeweled pin. Hotel State College was the site of a special tribute to Pauline on January 26, 1949. Three State College chapters of Beta Sigma Phi held a buffet supper to honor Pauline for her naming as an honorary member of the international sorority for business and professional women. Business and professional members of the group presented Pauline with a jeweled pin. In her acceptance speech, Pauline told the attendees about her prior summer's visit to the international headquarters in Kansas City, Missouri. The honor bestowed upon Pauline placed her in good company- previous recipients included Eva Johnson and Madame Curie.

A special marital milestone. A draping swag decorated the top of the card. *Mr. and Mrs. Warren Bryan Mack request the pleasure of your company in celebration of their Twenty-five Years of Marriage*. Approximately 300 people joined the Macks on September 8, 1949 to celebrate the occasion. There is mention of relatives in attendance, though Pauline's parents were no longer living. The guests included Penn State staff members from the departments of horticulture and chemistry and the Ellen H. Richards Institute, members of Beta Sigma Phi sorority, officers and past officers of Iota Sigma Pi, and neighbors within two blocks of the Macks' home. A few of the Macks' longstanding friends came from out of town to join the celebration. A buffet supper was held at St. Andrew's Episcopal Parish House on Frazier Street in State College. Assistant hostesses included Beta Sigma Phi business women's sorority members, as well as members of the committee in charge of the event. Jean Sherrill, Pauline's secretary, was a member of this committee.

After the buffet supper, guests adjourned to the high school auditorium for a musical program presented by the Glee Club and Junior Choir, youth groups from Saint Mary's School in Cresson. Reverend Father John Miller, Superintendent of St. Mary's and St. John's Schools, gave the invocation and introduced the performers. In looking through the program, I was amazed at the extent of the numbers and the diversity of offerings. The program ranged from such numbers as *Who's Afraid of the Bogey Man* and *Swing Your Partner* to *While the Angelus was Ringing*. German, Sicilian, Mexican, and Scotch tunes entertained the guests. Top Hat Tap, ballet, and the Highland Fling were featured. Following the final number, *It's a Most Unusual Day*, Reverend John N. Peabody, pastor of St. Andrew's Church, gave the benediction. The celebration, however, was not over. A reception at the Macks' home on East Hamilton Avenue followed the musical program.

The reception at the Macks' home was no less organized and entertaining. The invitation to the reception noted that guests should kindly follow the pink ribbon to avoid congestion. Informal music at the reception was provided by Mrs. Anne Predzin, Mrs. Lyman Jackson, Miss Ann Wisden, and Mrs. Evan Johnson. While at the Mack residence, guests assembled numbers on a card. The cards were collected for a door prize as guests departed. Mrs. Burton E. Livingston from Baltimore, Maryland drew for the lucky number. Mrs. Carl Marquardt from State College was the lucky winner. Another door prize went to Robert F. Fletcher from Boalsburg. His number was closest to the national debt.

Such an event would not be complete without floral decorations. The Parish House, the high school, and the Macks' home were graced by floral decorations created

by Peter Peahl of Penn State's horticultural department and arrangements from local florists sent by friends. A friend from Hawaii sent a lei via air.

The scope of this special event, including the diverse and numerous individuals involved in bringing it to fruition, parallels Pauline's professional collaborations and networking. Grand scale accomplishment is not an individual endeavor.

The Garvan Medal. September 1949 began with a momentous personal celebration that was very important to Pauline. Notification of the top honor available to women in the chemistry profession followed. At the meeting of the American Chemical Society in Atlantic City, Pauline was named as the recipient of the Garvan Medal. Pauline was selected for the award because of her work on the calcium chemistry of bone density, which she initiated in 1927. In discussing the photoelectric microdensitometer that was instrumental in her awarded nutrition research, Pauline highlighted the fact that "You can't get a good idea of it until you see the cussed thing" (Pines, 1950). A secondary factor was her work in directing graduate students who were conducting research in the fields of human nutrition and textile chemistry. Dr Mack was the eighth woman to receive the Garvan Medal. Previous winners included Dr. Florence Sabin, Dr. Icie Macy Hoobler, and Dr. Gerti Cori (a later recipient of a Nobel Prize in chemistry). On this occasion, Penn State's press release referred to Pauline as Dr. Pauline Beery Mack.

The Garvan Medal award was established in 1935 by chemical philanthropist and patent lawyer Francis P. Garvan, a former director of the Chemical Foundation. Emma Perry Carr received the first award in 1937. Eventually becoming the best-known prize for a woman in science, the establishment of this award reflected the sexual politics

behind women's prizes of the time. For more than a decade preceding 1935, female membership in the American Chemical Society (ACS) had been on the increase. A Women's Service Committee had been formed, primarily to serve social functions. Garvan was put on the spot by some committee members after he was heard joking to a friend that there were no women chemists yet. Garvan acknowledged his error and the likelihood that others shared his misperception. Attending a committee meeting, he offered his support in publicizing women's achievements. The ensuing Garvan Medal filled a void, however compensatory. It was rare that a woman was included on the ACS program even throughout the 1940s. It wasn't until 1967 that a woman won any other ACS prize.

Pauline received her Garvan Medal in April 1950 in Detroit, Michigan. Her medal address, *Chemistry of Bones in Relation to the Quantitative Evaluation of Bone Density from X-rays of Living Human Beings and Experimental Animals*, was given to the Division of Physical and Inorganic Chemistry on April 19. As a result of her award, a full-page photograph of Pauline graced the cover of *Chemical and Engineering News* (1950). In reporting on the award, the magazine went beyond Pauline's significant academic work to describe why Pauline was a deserving selection. It was noted that Pauline was bestowed with the faculties, determination, and physical endurance similar to that which allowed Curie, Meitner, and Coris to overcome discouragement and forge on to success. Seeing the immensity of human needs that would benefit from scientific research, Pauline dug in almost immediately upon her arrival at Penn State. Some of her students felt that Pauline's classes were so enjoyable and helpful that they were worthy of an admission fee. In writing an English composition, one of Pauline's freshman

chemistry students described Pauline as a large, strong-looking woman. He stated that her appearance of capability was really one of the keynotes to her personality and character.

Pauline recognized that her marital relationship was conducive to the work ethic that led to this award. Noted for probing into the nation's eating habits and the relationship between what people eat and their physical condition, Pauline couldn't remember ever having time to cook. Her rising at 5:00 a.m. with an 18-hour work day every day was not an issue with Warren. In speaking of her husband, Pauline noted that he was very liberal-minded about her work. If he hadn't been, she felt she would not have been able to do what she did. Pauline also stated that since Warren also worked hard, it all came out in the wash. Warren devoted many hours to each print, with many of them coming after midnight. It wouldn't be long before the devoted and indefatigable Dr. Mrs. Mack, with her superb sense of humor and zeal for her work, would be courted to take her capabilities and work ethic elsewhere.

Figure 6. Dr. Pauline Beery Mack. Photo courtesy of The Women's Collection, TWU.

A pivotal year. Pauline experienced the loss of a staff member and another honor before reaching a crucial decision in 1951. Pauline was testifying before the Federal Trade Commission in Washington in February. Dr. Maloise S. Dixon, a Penn State research assistant, was heading to Washington to deliver papers to Pauline. Despite

swerving into a ditch between Carlisle and Gettysburg and suffering head injuries, Dr. Dixon continued on to deliver the papers to Pauline. Dr. Dixon returned to Penn State and went back to work. The following day she fell ill, went into a coma, and was taken to Urological Hospital in Philadelphia. She died on February 23. In 1953 Pauline would acknowledge the contributions of the late Dr. Dixon for her assessment of X-rays for skeletal maturation in a study of bread enrichment in children's diets.

Priestley Lecturer. Dr. Wheeler P. Davey founded the Priestley Lecture series at Penn State in 1926. Named for the renowned English chemist and physicist Joseph Priestley, the series presents an outstanding scientist on an annual basis who lectures on a topic that borders between physical chemistry and another field. Up until the 25th anniversary of the series, all of the speakers had been men. Prior to 1951, one speaker would present a series of five papers. In honor of the silver anniversary celebration, the format was altered in 1951 to five speakers presenting one lecture each. On Tuesday, May 8, Dr. Mack delivered the second of the silver anniversary series of Priestley Lectures at 7:30 p.m. in 119 Osmond Laboratory. Her topic was *The Contributions and Potentialities of Household Chemistry*. With that address, Pauline became the first female Priestley Lecturer.

Figure 7. Priestley Lecturers- Dr. Mack top row, 2nd from right. Photo by author, 2008.

Simplifying housework. In June of 1951 Pauline traveled to North Canton, Ohio to address 50 home economics specialists who were attending the Hoover Home Institute summer school sponsored by Hoover Company, the appliance manufacturer. Pauline presented a work station cleaning technique that in a typical household would halve work time, eliminate a thousand feet of walking, and practically double the amount of dirt removed. Using this method, the housewife would gather the electric cleaner and other tools at one point. Prior to moving to another area, everything but the rug within an eight-foot square would be cleaned. Housewife testing of the new method revealed some interesting averages. Under the old conditions, housewives averaged three hours of cleaning time, 1,733 feet of walking, and removal of 13.9 ounces of dirt. With the new method, average time decreased to an hour and a quarter, 378 feet were walked, and dirt removed equaled 22.3 ounces. Dr. Mack, though acknowledging that housework was good exercise, recommended that from a psychological viewpoint, housewives would be better off simplifying their cleaning methods and getting their exercise in some other manner. For the woman who never wished to become a housewife and did not like housework and cooking, this point of view is not unexpected!

A Year of Transition

Pennsylvania's loss. The date was August 16, 1951. In Denton, Texas, the president of Texas State College for Women (TSCW) announced that Dr. Pauline Beery Mack, director of the Ellen H. Richards Institute of Pennsylvania State College, had been elected Dean of the College of Household Arts and Sciences. Pauline had been recruited by Dr. Guinn in what was described as an obvious effort to establish TSCW as one of the country's outstanding leaders in the field of household arts and

sciences. In an exclusive press release to the *Dallas Morning News*, TSCW declared that the Dallas-Denton area was about to become one of the nation's leaders in both nutrition and textile research. TSCW's long-anticipated plans were now coming to fruition and would serve the entire Southwest. Those plans included the opening of a new million-dollar home economics building that would also house a research center. The research staff, to be directed by Pauline, would include national leading research specialists in textiles and nutrition. Research grants totaling many thousands of dollars would support the center's operations within 30 days of its opening on campus. Future plans included the addition of more laboratory equipment, staff, and research money to make the work at TSCW of the highest value to Texas industry. Dr. Guinn encouraged Texas industries to bring their problems in nutrition and textiles to TSCW, pronouncing that the college developed this program to provide technical leadership to their vital industrial growth.

Pauline was to serve as an advisor during the organization of the newly-established College of Household Arts and Sciences at TSCW, while finishing the current academic year at Penn State in order to complete some research projects in human nutrition and textile chemistry. She would assume her full-time position in Texas in 1952. Dr. Mack would also remain co-director of the Center for Research in Child Development that was part of the University of Pennsylvania's School of Medicine. A collaborative plan was to be implemented whereby women conducting graduate work at TSCW could do some of their graduate work in Philadelphia at the Center.

A poignant *Centre Daily Times* editorial entitled "The College Suffers a Real Loss" published on September 5, 1951 opened with the following: "Alumni, friends, and fellow-faculty members of the College learned of Pauline Beery Mack's decision to go

elsewhere with a deep sense of loss." The editorial reflected on Pauline's being part and parcel of Penn State since 1919, noting that she was so closely connected with its progress that few thought she would ever separate from it. The editorial speculated that her new opportunity must offer a challenge to Pauline's inquiring mind or she would not have been interested in it. Rather than list her many achievements, the editorial instead declared a preference for remembering Pauline "as an excellent teacher whose zeal for research enabled her to go far in her field, so far, in fact, that she now is lost to the campus upon which she made her first major strides toward distinction." It was with reluctance that the editorial wished Pauline well, noting a desire to keep her for Penn State instead of yielding her to TSCW. Pauline, as the editorial so eloquently stated, had most certainly left her mark on Penn State through the Ellen H. Richards Institute and scientific advances.

Pauline's October 1951 report to George Haller, the new dean of the School of Chemistry and Physics at Penn State, perhaps sheds some light on her decision to accept Dr. Guinn's offer. Pauline informed Haller that after deciding to spend the remainder of her productive years in a more conducive environment as regards space and the absence of internal competition, she planned to remain at Penn State for about one year for the specific purpose of leaving the work she was responsible for in good shape. After 32 years she could not leave without fulfilling her obligations. Pauline also weighed in on the subject of money, noting that her decision to stay for a while was not influenced by monetary factors, as her new salary was better than her old one. Since she had put a substantial portion of her salary back into her work, Pauline remarked that it was a minor consideration.

Warren Mack's plans included retiring from Penn State after almost 30 years of service. He had several scientific books in the works and a desire to spend time on his woodcuts. Until he and Pauline had established a home in Denton, they would commute between Pennsylvania and Texas. Warren wasn't the only Pennsylvanian contemplating a move to Texas with Pauline. Before the news became public knowledge, Pauline and Warren asked George Vose to lunch with them at the Allencrest Tea Room at the NW corner of Beaver and Allen Streets in State College. They broke the news to George and asked him if he would move to TSCW in Texas. George did end up making the move during the first wave, along with a few others from Pauline's Penn State research staff. Several more followed later. Jean and Joe Sherrill, along with another couple, made the three-day car trip to Denton while they were deciding whether or not to make the move. Warren Mack drove them. Among those with textile expertise who chose to move to TSCW from Penn State were John Balog, George Wham, and Joe Sherrill. Dr. Sherrill, who became assistant dean for research at TSCW, and Dr. Wham, who became assistant dean for instruction at TSCW, aided Pauline in directing the new Texas enterprise.

During the transition period, Warren was involved in his work on the Penn State campus. He would go to Texas every so often to meet Pauline when she was there. In Helen Ludeman's presence on more than one occasion, Warren mentioned to Pauline that she had everyone helping her in Texas. He cautioned her against doing anything that would break that because he wanted her to be successful there.

A massive undertaking. Pauline did not travel lightly in making the transition to Texas. In addition to some of her staff members, Pauline moved much of her research work and some equipment to TSCW. Pauline hassled the Pennsylvania Department of

Health until receiving permission to take the nutritional files she had amassed during her years at Penn State. Among the files were all the records from the 18-year human nutrition studies that had cost in the neighborhood of $2,500,000.00 to perform. Given that only a portion of this research had been published, much remained to be analyzed and published at TSCW. Somewhere in the neighborhood of 50 tons of records and equipment made the truck trip from State College to Denton. Pauline also made arrangements to have a publication, which had been completed to lead type access but not printed, shipped to Texas. The driver of this truck, having been stopped, weighed, and fined for carrying excess weight, remarked that it was the heaviest, smallest volume load he had ever carried!

North Carolina 'possums. George Vose wryly remembered a side trip on the way to Texas. Pauline asked George to travel to Texas via North Carolina so that he could make arrangements at a biology supply house for the purchase of some opossums to be sent to TSCW. George had a very difficult time convincing the purchasing agent at TSCW to buy North Carolina 'possums when Texas had plenty of wild 'possums. Pauline was under the impression that the North Carolina 'possums were laboratory-raised, when in fact they were trapped native. George was challenged in constructing escape-proof pens for the wild 'possums, which thrived on canned dog food rather than vegetable and animal matter. With no 'possum progress in nutrition research, George left the pen door ajar one night so that the animals could join the Texas 'possum population. He informed Pauline that the 'possums had escaped.

Mixed emotions. While some of Pauline's State College staff were disappointed that they were not invited to Texas, others declined the offer. During one of the

transition-time trips back to State College, George Vose suggested that others might join Dr. Mack in Texas. A former member of her staff who had chosen to remain in State College immediately rebuffed George. George had made this return trip to Penn State to retrieve the original photodensitometer that Pauline had developed. Penn State had refused to allow Pauline to claim the more modern apparatus that had been developed. George loaded the original version in the trunk of his car and returned to Texas. The original photodensitometer adequately serviced their needs until the Starks provided funding to build a new one.

Figure 8. Part of Pauline's massive research files remaining in Texas today. Photo by author, August 2008.

Dr. Pauline Beery Mack inherited a secretary when she came to TSCW who was not used to such a high level of expectations. After Pauline bought a Dictaphone machine, the secretary quit. Pauline then brought her gossipy but very efficient secretary from Penn State to Texas.

Finalizing the Transition

A testimonial. Handwritten notes in the margins of Dr. Mary Willard's testimonial speech refer to furniture polish and goldfish, correcting blue books, and clean underneath. Unfortunately, the stories behind these cryptic notations are not evident. What are

apparent, however, are the honor and esteem bestowed upon Pauline at a testimonial luncheon given by National Sigma Delta Epsilon's Nu Chapter. At this January 7, 1952 event, Mary lauded her friend, a renowned and inspiring teacher who possessed a keen sense of humor. Mary highlighted the special help Pauline gave to her students, patient assistance to those who were slow and urging the bright to greater efforts. Mary reminded the audience of Pauline's prolific accomplishments as a systematic research worker and thorough investigator, as a versatile editor, as a capable organizer and enthusiastic administrator. Pauline's work in organizing both social and professional fraternities for women was acknowledged. One could possibly read between the lines of Mary's declaration that Pauline had built up courses and a Department, *in all but name*, in Household Science. It was noted that Pauline had administered and supported much of her vast research from grants-in-aid provided by a variety of foundations, industrial organizations, and the State [sic] of Pennsylvania. Dean Pauline Beery Mack, founder and member of Nu Chapter of Sigma Delta Epsilon, having brought reflected glory to her organization, received all the best wishes of her organization to bring with her to Denton.

Continued travels. On January 22, 1952 the Altrusa Club of State College met at the Hotel State College. Guest speaker was Dr. Albert Holtzinger, director of the chemistry laboratories at Penn State and district governor of the national organization of Lions, who spoke about the functions of a service club. Pauline, as president of the Altrusa Club, reminded members about their important business meeting that was to take place after the program. March 18 found Pauline in her role as TSCW dean in Dallas, Texas. She addressed how the College of Household Arts and Sciences could assist Texas industry at a joint meeting of the evening and luncheon groups of the Dallas chapter of

TSCW Ex-Students. Pauline described the textile research laboratories that had been established for the study and testing of natural and synthetic fabrics. She also talked about the study of food and nutrition, with tests being offered for children and cooperation with neighboring school lunch programs.

Pauline's new research home. Pauline's new home at TSCW was the College of Household Arts and Sciences. Similar to other buildings on campus, it was of Georgian-type architecture. The four-story building housed twenty-two classrooms and offices. Inside were two model patios, glassed in, and six model kitchens outfitted with the latest electrical equipment. Three large laboratories dedicated to food research were located on the second floor. Animal laboratories were positioned on the third floor, along with a kitchen used to prepare diets for experiments. The advanced textile laboratory had a small room where constant temperature and humidity could be maintained. Larger rooms held equipment used for measuring and testing the strength of fibers, color fasting, and other research.

The week of March 24, 1952 was replete with programs held to honor the dedication of the new building and the inauguration of the expanded program for the College of Household Arts and Sciences at TSCW. The building was open at various times for inspections and exhibits from Tuesday through Saturday. The formal Open House and dedication program were held on Thursday, March 27. Extensive presentations, along with musical, dance, and drama selections and programs, took place during the week. Pauline gave the opening address of the Series of Dedication Symposia to be held that week. Nearly 50 speakers from across the country were invited to participate in the events. Symposia topics included home management, child

development, nursery education, family relations, housing and household equipment, textile technology, textile and costume design and clothing construction, large scale detergency, the relationship of radio, television and the press to the household arts and sciences, foods and nutrition, and trends in home economics education. The week concluded with a conference of future homemakers that featured careers for girls in the household arts and sciences. Pauline and large scale continued to be synonymous! A *Dallas Morning News* article on the dedication ceremony referenced research on colony rats and George Vose's infamous opossums (who had not yet made their nocturnal flight to freedom with George's surreptitious assistance).

Dual roles continue. B. Clark Prescott of Coin Operated Laundries & Equipment, Tacoma, Washington sent a letter to the Department of Public Information on April 15, 1952. He was seeking information on sonic washing, one of the research areas under Pauline's direction at Penn State. The query was forwarded to Pauline, who wrote a response on April 25 as Director of the Ellen H. Richards Institute, Penn State. Pauline summarized the research to date and her perspective that an affordable, improved sonic washer could be devised. Benefits shown by a smaller Australian machine indicated great conservation of fabric strength and reduction in shrinkage with sonic methods as opposed to mechanical washing.

May 30 to June 2, 1952 found many ex-students of TSCW appearing in Denton for the annual homecoming reunion. This particular homecoming was held in honor of both June graduates and the 25th anniversary of the class of 1927. Pauline was the speaker at the Saturday night, May 31, banquet. Pauline presented on the topic of the expanding research horizon. June 2 was not only the end of TSCW's homecoming reunion. On this

day the TSCW Board of Regents unanimously approved the creation of a doctoral program in the College of Household Arts and Sciences as of September 1952. A caveat stated that no new course offerings required by the creation of the doctoral program would be supported by state or local educational funds, except as authorized by H.B. 426. Pauline went on the road again, heading "home" to Pennsylvania to receive another honor.

On June 9, 1952 Pauline was one of three women to receive an honorary degree from the oldest women's college in the nation, Moravian College for Women. Pauline was presented with a doctor of science degree at commencement exercises held in Central Moravian Church, Bethlehem, Pennsylvania. Texas news coverage of the event laid claim to Pauline as the Dean of the College of Household Arts and Sciences at TSCW. At the same time, Pennsylvania newspapers acknowledged Pauline as the Director of the Ellen H. Richards Institute at Penn State. One of the other honorees was Miss Marion Anderson, a world famous contralto, who received a degree of doctor of music. The renowned singer had prior honors from the National Association for the Advancement of Colored People and the Federation of Jewish Women's Organizations. She had also received the Bok award in 1940 as leading citizen of her birth city, Philadelphia. The honorary degree that Pauline received this day would turn out to be far less significant than the opportunity to meet up with Marion Anderson. In a few short weeks Marion would provide a most poignant and forever meaningful favor for Pauline.

Penn State provided a press release on Friday, June 13, 1952 regarding Warren Mack's retirement. The announcement was made by Penn State President Milton S. Eisenhower following approval of the retirement by the Board of Trustees.

Warren's career as professor and head of the department of horticulture at Penn State would end on August 31, his effective date of retirement. He would retire with emeritus rank. Pauline and Warren planned to move to their new home in Denton in August.

Pauline was in Texas on June 23, 1952. Her entering the TSCW Board of Regents meeting is recorded in the minutes. The doctoral program approved at the June 2 meeting was a topic of discussion. The Board committee met with Vernon McGee, Director of the Legislative Budget Board, on that day to present their reasons for authorizing the new doctoral program. Concern had been expressed that individual legislators who were not familiar with the details might believe that the Regents, while following the letter of Section 20 of H. B. 426, had disregarded its intent. McGee was convinced by the Regents' compelling reasons for authorizing the program and would arrange a time for the College Regents and Administration to present their facts to a group of key legislators making up the Legislative Budget Board. The Regents reiterated the rationale for allowing the program: (a) TSCW produced the largest undergraduate and graduate output in home economics of any institute in Texas that year; (b) TSCW possessed the most distinguished home economics teaching and research staff in the entire Southwest; and (c) material resources and physical facilities in home economics were unparalleled elsewhere in the Southwest. Many other reasons were given, including the obligation to allow Pauline's and her staff's students who had previously begun doctoral study the opportunity to complete their work. The Board unanimously reaffirmed its June 2 decision to approve the doctoral program. Somewhere around this date the beginning of a tragic loss was set in motion in Pennsylvania.

A terrible blow. In the midst of his retirement plans, Warren Mack suffered a heart attack and was admitted to Urological Hospital in Philadelphia. Pauline remained in Philadelphia during Warren's two-week hospital stay. While in Philadelphia, Pauline arranged for Marion Anderson to come to the hospital to sing for Warren. He was very appreciative of the gesture. Sunday morning, July 6, 1952, Warren suffered another heart attack and died. Services for Dr. Warren Bryan Mack were held at St. Andrew's Episcopal Church in State College. The Memorial Record for Friends and Relatives included the comforting words of Tennyson's *Crossing the Bar*. Warren was interred in Centre County Memorial Park next to Pauline's parents. At age 56 he had put out to sea to meet his Pilot face to face. Pauline would make the final move to Texas, to the house with the perfect spot for Warren's art studio above the garage, alone.

Warren's death was unexpected and devastating for Pauline. She was dealt a terrible blow and would undergo a major transition in her life without any family support. Jean Sherrill does not think that Pauline would have accepted the position in Texas if she had known what was to come. George Vose, who saw how solid Pauline was, would end up thinking she recovered from her loss fairly quickly. While she may have presented a stoic front, future reflections would reveal the deepness of this loss.

Figure 9. Warren's unrealized studio in Denton, Texas. Photo by author, August 2008.

A memorial for Warren was established at Penn State in May 1953. Bookshelves were to be located in the Horticulture Seminar Room of the Plant Industries Building. Horticultural books, with appropriate inscriptions, would be available for undergraduate and graduate students. In 1955 the Society of American Graphic Artists donated a collection of more than 200 prints to Penn State in memory of Warren. Pauline added more than 40 of Warren's prints to this collection. The Society also donated prize-winning prints from 1959, 1960, and 1961 to the collection at Penn State. Lyn Ward, a well-known American wood engraver, established the $100 awards with money donated by Pauline.

Pauline Beery Mack's Texas Years

The Second of Two Universities

Somehow it is not surprising, given Pauline's history, that in accepting Dr. Guinn's persuasive invitation she became a staff member at the only university in the United States founded specifically for women. Pauline's new university was established by legislation in 1901 following a decade of effort by individuals interested in women's education. Among the active proponents were Mrs. Helen Stoddard, State President of the Women's Christian Temperance Union of Texas, Mrs. Duncan as representative of the Texas Woman's Press Association, and the members of the Texas Legislature House of Representatives. The Girls Industrial Institute and College of Texas was to be built in Denton, a site selected from among 14 cities as the location for the new institution. The name was changed to Girls Industrial College (GIC) by the time the cornerstone of the first building was put in place. GIC's first President, Cree T. Work, dedicated GIC "to the

young womanhood of our great State" (Official Texas, 1974, p. 5) and went on to specify his objectives for the new college:

> In short, we want to meet the need of our times in training women who will be competent, intelligent and refined: well fitted for self-support if this should be necessary; thoroughly prepared for woman's work in the industrial and commercial world if they so choose to labor; well trained for companionship with worthy manhood and for motherhood, when this is desired.

The first building on campus opened to 14 faculty members and 186 students when classes started on September 23, 1903. It remained the only academic building for years, with wings added in 1916. President Work guided the early stages of the institution, renamed College of Industrial Arts in 1905, energetically and wisely. Laying a wise foundation was not an easy task. The early years reflected the conflicts of the era. While many supported the college, there were many who did not. Some thought women should be prepared to find a place in business or in a profession, while others believed that women belonged in the home. Controversy also existed between the merits of a practical education versus the traditional classical studies. The new college bridged this gap by emphasizing a literary education in the first two years of study and using the last two years to focus on attaining and applying practical skills. That practical aspect was reflected in a graduation requirement in effect for the first twelve years of the college's existence. In order to graduate, a girl had to be able to make her graduation dress.

By the time Pauline was hired in August 1951, the college was known by the name it had taken in 1934- Texas State College for Women (TSCW). Grown considerably from its early days, TSCW's programs in the fall of 1950 included 63

different clusters of courses leading to the B.A. and B.S. degrees and 13 majors leading to master's degrees. Besides being the first and only university in the United States founded specifically for women, TSCW was the first college in Texas to offer college credits and degrees in many areas- advertising, health and physical education, and occupational therapy to name a few. TSCW was also the first college in Texas to grant degrees in home economics and the first in the nation to offer graduate work leading to master's degrees.

In 1951, under President John A. Guinn's leadership, human and material resources were brought together to enable a large scale research program.
Dr. Pauline Beery Mack, with the assistants she brought from Penn State and thousands of dollars in grants, was a key component to fulfilling Guinn's ambitious goals. In announcing Pauline's appointment, Guinn noted TSCW's history of leadership in household arts and related research. Given the many demands made upon TSCW in this field, Guinn proclaimed that they were accepting the challenge of taking TSCW forward to new heights in teaching and also in extensive research financed by private sources.

When the new College of Household Arts and Sciences was formally inaugurated on March 27, 1952, Guinn referred to the "splendid beginning" that had been reached on "possibly the most dramatic of our recent pioneering ventures… namely the first major program of research to be undertaken by a woman's college" (Thompson, 1982, p. 136). Guinn also referred to the presence of the advance guard of seven full-time research scientists and noted that in the months to come, the number of those workers would double and then double once more. On August 1, 1952, less than a year after Pauline's hiring was announced, TSCW's bulletin announced its first college majors leading to

doctoral degrees. Areas of study to earn a Ph.D. degree included foods and nutrition, textiles and clothing, clothing and costume design, and home economics. Graduate students could earn the Ed.D. degree through a major in home economics education. By the end of her transition year from Penn State, Pauline had already delivered big time. President Guinn's declarations that the appointment of Dr. Mack was another landmark in the history of education in Texas and also a landmark in the industrial development of Texas were on their way to being justified.

In 1957 TSCW assumed the name it retains to this day, Texas Woman's University (TWU), though male students have been admitted since 1972. Regardless of the name, the University with modest beginnings had a student population in excess of 6,500 in 1974. The 270-acre main campus had 44 buildings by then and was referred to as a cosmopolitan multipurpose university. Growth continues, as spring semester enrollment in 2007 approximated 11,263 students.

Pauline, a woman of multiple contrasts, had segued from an institution founded to afford a place where sons may be educated to a fitness for a high position in any of the walks of life to one established for the practical education and domestic training of daughters. Following her rich legacy at Penn State, Dr. Pauline Beery Mack would become a Texas woman larger than life in her second of two universities.

Landmark Pioneers

August in Denton, Texas is not for the faint of heart. Though it is early morning, the soon-to-be 105 degree, humid air is an omnipresent cloak. As I scan the horizon, my initial vantage point does not reveal the extent of the TWU campus. While reconciling the view with my expectations, a 13-foot sculpture carved out of a 30-ton block of

Georgia white Cherokee marble diverts my attention. Closing in, I read Jessie H. Humphries' 1936 dedication inscribed on the monument: "Marking a trail in a pathless wilderness, pressing forward with unswerving courage, she met each untried situation with a resourcefulness equal to the need." Dr. Pauline Beery Mack, Dr. Guinn's landmark, could be described in similar fashion, I reflected. I read on:

> With a glad heart she brought to her frontier family her homeland's cultural heritage. With delicate spiritual sensitiveness she illumined the dullness of routine and the loneliness of isolation with beauty and with awareness of her value to civilization. Such was the pioneer woman, the unsung saint of the nation's immortals.

Since Texas erected the Pioneer Woman monument in 1936 to commemorate 100 years of Texas independence, this symbolic pioneer landmark was there to greet Dr. Guinn's landmark pioneer as well.

Figure 10. TWU Landmark Pioneers: Dr. Pauline Mack, photo courtesy of The Women's Collection, TWU & Pioneer Woman Monument, photo by author, August 2008.

Rounding out the Fifties in Texas

A new home. Kelsey, Kelsey, Collister, and Hickey currently have their law offices in what was once a lovely home at 2225 East McKinney Street in Denton. Barely daring to breath in anticipation, I explained to Attorney R. H. Kelsey the purpose of my phone call and why I was hoping he would allow my request to investigate his property. We arranged to meet early the following morning at what was once the home selected by Pauline and Warren and what would be Pauline's residence for many years. Driving up, I was impressed by the beautiful columns of the house. Later on, George Vose would tell me that Pauline loved the house because of those columns. Some of the TSCW faculty thought Pauline was living above her means, but George had seen her house in State College and knew the two were comparable.

Attorney Kelsey said that though the house was built in the 1920s, the exact timing was unknown because the original owners probably paid cash to build it and didn't leave a paper trail. Four acres remain with the house today. The house was sheathed in redwood, so there is no bug damage. It still has the original floors, paneling, doors, and tile. The front room was probably screened in and then closed after air conditioning was added in a 1955 renovation by Pauline. Pauline hated air conditioning, but eventually recognized the need for it in Texas and capitulated. Up and down the stairs, in and out of rooms, inside and outside, exploring the home was akin to visiting another era. The bathrooms and kitchen reflected Pauline's time, but were in beautiful condition.

The home no longer contained the many family heirlooms Pauline had brought to Denton. When she lived here, antique Victorian chairs and settees belonging to Pauline's

grandmother furnished the living room. Also in the living room was a grandfather clock that came from the home of Warren's great grandfather. A music room housed a grand piano that Warren had given to Pauline. The home was filled with accessories, many of which had been wedding gifts. There were also many gifts from former students displayed in an upstairs hallway. One of the items was a doll in a native Korean dancer's costume that was made by Sook He Kim, a graduate student from Korea.

Fourteen rooms made up the main part of the house at that time. Pauline had them divided into areas for relaxation, entertainment, and research. She frequently worked with her graduate students at home, noting that there were fewer interruptions and distractions. Students could spread out their materials in certain areas of the home and leave them there between sessions, something that could not be done on campus. Those work areas could be closed off from view.

Pauline had an upstairs study formed by two rooms. A hand-carved Oriental figure of reddish ebony sat on top of her television, which was in viewing range of her desk. Representing the father of good will and happiness, according to Pauline, it too was a gift from a graduate student. Pauline watched her favorite programs in the evening while doing the type of paperwork that didn't require much concentration. Her special program, however, was a daytime soap opera, *As the World Turns*. Without the recording capabilities we have today, someone would have to watch the show and update Pauline if she missed the show while travelling. On one occasion, a group from TWU went to Dallas for a meeting. Pauline parted from the group at one point, saying that she had some things to attend to and would see them at a particular time. The group thought they would use the time to visit one of the hotels. When they entered the lobby, there was

Pauline, watching her show! Some of them started to watch the program regularly and Pauline enjoyed discussing the show with them. George Vose recalled the time when he was driving Pauline and he had to get to the city in time for her to see her soap opera. Someone was watching the television, so Pauline, never shy, asked to change the channel.

A sun terrace on the top of the breezeway that connected the house and the garage was accessible from the second floor. I stood on the terrace, which had served as a place for Pauline to relax on warm evenings, contemplating the far end. The terrace led to the enclosed room and study above the garage that was to have been Warren's studio. Pauline had followed through on Warren's landscaping plans when she moved here and planted accordingly. Pauline's lovely garden area was not typical of the times in Denton. The garden and raised terrace that Warren planned were carefully preserved while Pauline lived here, making a beautiful setting for the wedding of one of Dr. Mack's students. Though Warren hadn't survived to retire in Texas, memories of him were omnipresent.

Figure 11. A beautiful site for a student's wedding, Denton. Photo by author, June 2008.

Looking at the expansive yard, I could picture Pauline's graduate students racing across the yard in pursuit of a cat. When she first took up residence here, she had several

cats, some indoor and some outdoor. All her students knew to watch out for the cats. If they accidentally let one out, they had to chase it until captured. Sometimes that involved treks across several fields. Dr. Mack enjoyed attending to the nutrition of old alley cats, giving them sleek, new coats by feeding them well. Later on in life Pauline replaced cats with poodles.

Pauline was infamous for her driving, both on the road and in her garage. On one occasion, she attempted to turn her old Mercury around in the garage. The car became stuck in the garage and help had to be summoned. At about 5-feet tall, Pauline didn't look over the steering wheel, she looked under it. Betty Alford vividly recalls that they avoided Pauline on the highway if they saw her coming because driving was not one of her strengths. Eventually Dr. Mack gave up driving and the student who currently lived with her would be her chauffeur.

Figure 12. Pauline's East McKinney home: Front, Rear, Interior. Photos by author, June 2008.

George Vose also chauffeured Pauline on many occasions. During their drives, George and Pauline would talk about her history and his, with Pauline confiding that being a female was an impediment. She had quite a battle to get what she wanted. At one point during her Texas years, Pauline volunteered to give a nutrition course once a week

at Baylor Dental School in exchange for research help. George drove her to her 8:00 a.m. classes and sat in on some of her lectures. The class was crowded, and George thinks all the students were male. Pauline utilized her set of old-fashioned slides and humor, developing a good rapport with the students. They enjoyed her class. Back at TWU, Pauline was a role model for her graduate students. She would put Chinese students in George's Electron Microscopy class to help them learn English. Pauline especially liked the Chinese students and had sympathy for them and their visa issues.

A very public figure. Pauline's pattern of visibility and networking continued in Texas. She was known for her adeptness in dealing with individuals from all walks of life and was able to adjust her ways to their interests. Capable of talking to people on multiple levels, Pauline was gifted at being in touch with people. As Jean Sherrill pointed out, Pauline was always flitting off to some place. This flitting and the visibility it brought to TSCW supported both Pauline's and Dr. Guinn's goals.

In February 1953 nearly 1200 dairymen gathered in Dallas for the 45th annual convention of the Dairy Products Institute of Texas. Pauline and Dr. Guinn were on hand to discuss a milk research project for Texas and the nation. They proposed a huge milk and nutrition research program with a price tag of more than $100,000.00 that would involve approximately 15,000 subjects from birth through age ninety of many ethnic backgrounds.

Teenagers' poor eating habits were a focal point in June 1953 as Pauline provided information to about 200 homemaking teachers from Northeast Texas. She had recently released some of the findings from an 18-year continuous study of family eating habits. Findings revealed that teenage girls were the poorest-fed children of the family, with

teenage boys faring only slightly better. Pauline acknowledged how difficult it was to reach teenagers, given their growing independence from their parents. Modeling after movie stars was also an issue for girls. Her declaration that science was finding that illnesses of middle and old age are rooted in teenage eating habits could still be made today.

Having spent some time back East in late September 1953, Pauline flew from New York City to San Antonio to serve as the guest speaker at the first meeting of the American Association of University Women. Her October 3 lecture at the Menger Hotel focused on *Science Enters the Home*. Later that month the issue of overeating as the country's number one health issue was on the table. A special course was in the works to be held at the Dallas Health Museum. Pauline was a consultant for the series. The basic plan was for participants to band together in classes to both lose weight and to maintain the loss. Careful instruction would be provided at each step along the way. Sponsored by the city health department in partnership with the museum, the course was open to men and women identified by their doctors as being overweight due to overeating. Pauline spoke at the October 29 luncheon that was held as the opening event for the nutrition program. Nutrition experts, city health department staff, and members of the Health Museum Guild were in attendance. In her talk, Pauline spoke of the disorders that occur due to poor diets. She explained that the value of reducing through such courses is in assisting dieters in knowing what they are doing, stressing that a self-imposed reducing diet is a health hazard. TSCW research facilities were to be available for the classes so participants would know their nutritional standings prior to dieting. A sixteen-week series

of classes got underway on March 22, 1954. Dr. Edwin Rippy, a specialist in internal medicine, was the first speaker.

Teenage nutrition came to the forefront in March 1954 with a Florida conference and the release of another research project. Pauline, Dr. Robert W. Higgins (director of the TSCW Department of Chemistry), and two Penn State staff members had collaborated on a study that showed the value of orange juice in teenagers' diets. The data came from the Pennsylvania Studies in Human Nutrition and were statistically analyzed at TSCW. Given the inadequate intake of Vitamin C during the teen years, Pauline recommended snacks such as orange juice that provide fatigue resistance along with high nutritional values. In the study, youngsters 10 to 19 years of age were able to do more push-ups and sit-ups and had improved speed and accuracy on particular tasks after consuming a glass of orange juice. Pauline traveled to Lakeland, Florida to present her findings on March 12 at the Conference on Research in Medicine and Nutrition of the Florida Citrus Commission. Her itinerary included a listing of the science writers, referred to by the *Lakeland Ledger* as Florida-junketing, from around the country who were attending the conference. The year ended with a national spotlight on this research when McCall's magazine reported the results of the study.

Returning from Florida, Pauline served as a presenter on April 2 at the Texas Dietetic Association. May brought with it National Secretaries Week and the second annual Institute for Secretaries at the Baker Hotel in Dallas. Pauline was one of the four principal speakers for the institute, addressing the approximately 300 attendees on the topic of *Research for Everyday Living*.

From the Texas State Teachers Association presentation on *Food for Thought-Trends in Nutritional Research,* to greetings at the fifth annual Homestead Improvement Workshop at TSCW, and then on to Minneapolis to present the relationship of nutrition to the sizes and shapes of children at the American Home Economics Association meeting, Pauline continued her numerous appearances in 1955. No matter whether the venue was a large convention or the local Dental Assistants' Association, Pauline was there to present the work taking place in Texas. One of these meetings took place at the Lone Star Gas Company in the fall of 1955. Pauline told the school and media attendees that having hung enough crepe over teenage undernourishment, the researchers had determined to find out what could be done about it. Lever Brothers Company provided financial support for a study that involved some 122 TSCW girls in a school year of careful eating. The girls shared their story on a color film geared to the interest levels of teenagers. Those who were in the experimental group using 30% to 35% fat had the most improvement in increased energy, better skin condition, and more normal weight.
Ten years of textile and detergency research also had a place on the speakers' circuit in 1955. Pauline took the East Coast, presenting at the Tenth Annual Convention of the Diaper Service Institute of America in New York City. Joe Sherrill headed to Los Angeles for a presentation to the Linen Supply Association of America.

After hanging the crepe on teenage undernourishment, Pauline in 1956 advocated for what she termed special, super-duper attention to the diets of children with disabilities. Results from work conducted with patients hospitalized in Pennsylvania indicated that a top-notch diet might accelerate growth in polio and cerebral palsy patients. While principles of good nutrition apply to all children, extra attention was

needed for children with disabilities. Pauline also addressed the numerous problems of aging, including brittle bones, poor memory issues, senile blindness, and anemia. While reviewing major research findings on geriatric nutrition in a speech to the division on aging of the Council of Social Agencies, she pointed out that many of these problems could be prevented by proper diets. Pauline's research had taken place at Penn State, TWU, institutions for the aged in Pennsylvania and Dallas, and the Kerrville, Texas state home for people with senility.

Nelda Childers Stark Laboratory. In addition to the new College of Household Arts and Sciences, the old Home Economics Building at TSCW was converted to space for the TSCW Research Center. Home to several laboratories, the building also had an air-conditioned reading room for graduate students. In honor of its patron, the building became the home of the Nelda Childers Stark Laboratory for Human Nutrition Research. Nelda Childers Stark, a TSCW alumna, and her husband, H. Lutcher Stark, provided funding starting in 1953 in support of making the laboratory one of the nation's best equipped. The Starks' initial $25,000.00 contribution created the laboratory and helped to equip it. This was followed by a $2,500.00 contribution in 1954 for the purchase of a refrigerated tank unit and other items. Their deeply appreciated 1956 grant of $25,000.00 enabled Pauline and George Vose to build an updated Assembly for roentgenographic measurement of bone density, described in great technical detail by Mack, Vose, and Nelson (1959). Pauline and George traveled to Washington, D. C. in late 1959 to address the National Institute of Health. Their two-day workshop on bone density research presented the Mack technique for measuring bone density.

In the preface to a nutrition study involving pre-school and elementary children in Texas (Mack et al., 1958), TWU President Guinn noted that the Nelda Childers Stark Laboratory was uniquely equipped to study growth, skeletal and dental status, status of the body's non-skeletal tissues, body functions, and body chemistry in connection with specific diet regimens to contribute to the common body of knowledge in the field of human nutrition. This particular study of mid-session feeding of orange juice as an extension of the school lunch program was one of many geared to improving food habits and general well-being. Grant funding for the study came from The Florida Citrus Commission.

Nelda was a very generous alumna and Dr. Guinn was not one to ever miss an opportunity. Present during a very hot graduation ceremony, Nelda remarked that she was going to air condition the main auditorium. Dr, Guinn announced it to all present right there during the ceremony!

Figure 13. Dr. Mack's Realm. Photo courtesy of The Women's Collection, TWU.

Technology of the times. The graduate student operating IBM data processing equipment at the University was graduating in the spring of 1954. George Vose was worried about locating a qualified replacement to operate all of their IBM equipment. He

discovered through incidental conversation that Jim Cain, one of his flying students, was experienced with such equipment. Jim came on board and did data processing jobs for both George and Dr. Mack, with ~90% of the jobs initiated by her. In this time period, keypunching data into IBM cards was a time-consuming but uncomplicated chore. Jim trained students to operate the keypunch machines.

Jim would take the keypunched cards that contained the data and run them through the IBM system. The system was capable of preparing reports for Dr. Mack by reading the punched cards. The cards could be run in various sequences to obtain different information. They had firmware at that time, so Jim had to change the wires around on a plug board to get different calculations. The reports generated were used to track information on the research studies. We now have software instead of firmware and keyboards have replaced punching cards. Today, data can be entered quickly and easily, with immediate processing at tremendous speed. That was not the case in the 1950s!

Dr. Mack was seated behind her desk in her office when Jim first met her, surrounded by three or four other people. Given his young age and unfamiliarity with all those present, he was a bit intimidated at first. Dr. Mack was very strong in her ambitions to get things done, but Jim found her easy to work for over the course of their purely business association. He perceived that Dr. Mack was well-liked by everyone. He would take the reports to her; she would examine the results, and then ask for other reports. Dr. Mack knew what she wanted and wanted it done quickly. They got it done. She put the data to good use in her research reports. Jim left the University when he was drafted into the U.S. Army in December 1955. He and George Vose, the finest gentleman he has ever met, remain friends to this day.

Jim Cain entered the Army prior to Jessie Ashby's 1956 arrival on campus. Jessie, married and in need of tuition money, found out from a friend that she could get a job at the University if she could keypunch. Jessie headed off to Dallas to a school on Pearl Street and took an 8-day course in keypunching. When her friend, who worked at the University, took her to see Dr. Mack, she was interviewed and hired the same day. During the interview, Dr. Mack asked her if she was married, if she had any children, her religion, and her experience- typical interview questions of the time. Initially, Jessie anticipated working part time from April to August doing punched card data entry. Though she expected to be done in August, she ended up staying 42 years. She has vivid memories of 11,428, the number of participants in the Pennsylvania Mass Nutrition Studies whose data they had. Each individual file contained several pieces of data. It was Jessie's job to punch the recorded data into the punched cards. Dr. Mack had brought IBM equipment with her from Pennsylvania, including a key punch, verifier, and sorter for use in this task. After filling out papers in the comptroller's office on the day she was interviewed and hired, Jessie was shown the key punch machine and a large stack of coding paper that was almost solid with numbers. There were 80 columns on the punched cards. Jessie actually started punching data the very day she was hired.

Dr. Mack would work all hours of the day and night, sometimes on two or three hours of sleep. Not only did she believe in working hard, she also expected her employees to do so. Jessie and her colleagues worked 44 hours a week in the beginning and any other hours that Dr. Mack could convince them were necessary. Awed and scared of Dr. Mack at first, Jessie could understand what Dr. Mack wanted done. Jessie was adept at finding coding errors and developed additional skills through courses with

IBM. Her new boss, up-to-date and enthusiastic, would end up being very good to her and, Jessie thought, that probably was true for most of the others who worked for Dr. Mack. Perhaps that is one of the reasons that most of them didn't say no to her. Dr. Mack was decisive and quickly attended to petty grievances. Fed up with women who were hot or cold, putting cardboard on or removing it from the vents, Jessie wrote a note that she was going to give a two-week notice because she couldn't get along with the women over the temperature. Dr. Mack didn't want Jessie to quit and told her that only one person would be allowed to touch the air conditioning. Dr. Mack lobbied Dr. Guinn for pay raises for her employees. Jessie felt that if you were loyal and a good employee, Dr. Mack was behind you 100%. Most of those who worked for her for a long period of time grew to love her, though sometimes something would happen to break their trust. Jessie believed that one or two employees probably left hating Dr. Mack.

Over time Jessie discerned that Dr. Mack had her own way of doing things. Dr. Mack's perception was that rules were just made to be broken, Jessie thought. If they didn't suit Dr. Mack, she found a way around them. The people who worked for Dr. Mack who were primarily there for research purposes were paid out of raised, or soft, funds that needed to be renewed either by the State of Texas Legislature every two years or by grants. Jessie couldn't fathom the stress that a situation like that might place on one. Fortunately, Dr. Mack excelled at garnering support, going out to raise money. She was very persuasive in her explanations of the needs and possibilities for future programs that would benefit mankind. Jessie was fascinated by Dr. Mack's tale regarding Grace Kelly's father. Dr. Mack told of making an appointment to sit with Mr. Kelly at lunch, as that was the only way to see such a busy individual. Dr. Mack had done a study at a school

that his daughter, Grace, had attended. Grace Kelly was one of the study participants. Dr. Mack sat at the table while he ate, her efforts focused on obtaining funding from him.

One of Jessie's responsibilities was doing statistical analyses for graduate students. Jessie came to work during one of her pregnancies on Friday and delivered on Saturday. Friday was the day that dissertations had to be turned in for summer graduation. The graduate students were praying she wouldn't deliver before then. Two weeks overdue, Jessie got the analyses done. When Jessie had told Pauline she was pregnant, Pauline told her she could have two weeks off! Pauline held a baby shower for Jessie at her house in 1964, giving her two peignoir sets that she had purchased at a factory. Jessie did return to work two weeks after having her baby, but took three weeks off the second time around.

Dr. Mack always had additional work for Jessie to do, so she stayed on. TWU permitted employees to take one course a semester if their director allowed it. Dr. Mack always let Jessie do this, so she earned her undergraduate degree one course at a time. It took her some 20 years to do this. Six years after earning her undergraduate degree, Jessie received her Master's Degree in Nutrition.

A growing reputation. TWU's reputation was greatly enhanced through the work emerging from the College of Household Arts and Sciences. Gay Simpson (1958), Fashion Editor for the Dallas Morning News, provided a detailed explanation of the work that was taking place in the field of fabric research under its brilliant dean, Dr. Pauline Beery Mack. In discussing the $25,000.00 electronic microscope used to magnify cotton fibers up to 30,000 times, Simpson declared that with the energetic dean concentrating on fabric, the private life of any single fiber was nil. Tensile testing, color

fastness, and shrinkage were all under examination. Contracts between the university and the state were in place to ensure that fabrics used in men's and boys' clothes in institutions maintained their appearance and performed as desired. Dr. Fenton Keyes, TWU dean of faculty and graduate studies, acknowledged the diversity of Pauline's work and the national attention it had garnered, declaring that Dean Mack's efforts knew no boundaries. As Helen Ludeman pointed out, Dr. Mack was the one who showed Dr. Guinn how to develop a program that differed from others in Texas.

A clever end to 1959. As the fifties came to a close, Pauline's savvy is well-illustrated by her tweaking of the Maid of Cotton event, noted by a reporter as a time when market prices yielded to feminine pulchritude. Historically, the Dallas Cotton Exchange had always feted the reigning queen when she visited Dallas. Pauline thought it would be a good idea if the Exchange members participated in choosing the girl who could possibly wind up representing the cotton industry. TWU students picked 15 of their classmates as finalists to try out as 1960 Maid of Cotton entries. Dr. Sammie Ross, dean of women, accompanied the entrants. The contestants modeled casual cotton dresses, some which were their own original designs. Following that, they appeared in full-skirted formals, with each girl providing information on the history, the types, the uses or the distribution of cotton. Prior to the review, Pauline had brought the members of the Cotton Exchange up to date on the research on cotton taking place at TWU and the scholarships that were given. In case you were wondering, Miss Genevieve Hogue, 19, of Commerce, was the first place winner. The real winner, in all probability, was the research program at TWU.

Accumulated honors. On College Day, October 18, 1952, freshman students at Western College for Women in Ohio were officially acknowledged as full-fledged members of the college community. In recognition of her contribution to the knowledge of the chemistry of food nutrition, Dean Pauline Beery Mack of TSCW was presented an honorary doctor of science degree. This honor was bestowed four months after her honorary degree from Moravian College for Women, which was given for her work as specialist and teacher in the field of public health and child development.

Pauline received another significant honor in May of 1953 when Pan-American Medical Association made her a member of the executive committee of its recently elected Section of Therapeutics and Nutritional Research. Headquartered in New York, the association's primary objective was promoting closer relations and improved understanding among parties with interest in the medical sciences in the Western Hemisphere.

News came to Texas in February 1958 that Great Britain's Royal Society of Health had elected Pauline to its membership. Membership in the Society, which had Queen Elizabeth as its patron, was by invitation only. Pauline's election was based on her distinguished career of research in the field of public health nutrition. Pauline had also been recently elected into the Society of Chemical Industry in Great Britain.

The 1950s ended with another honor for Pauline, with her designation as one of 10 distinguished professors in Texas institutions of higher learning, representing a diversity of fields. Pauline was named *Piper Professor of 1959* in recognition of her work as dean and director of research at TWU's College of Household Arts and Sciences. This was the inaugural year for the awards, made possible by an endowment created to honor

outstanding teachers and researchers. The selection committee of the San Antonio Piper Foundation selected Pauline and nine others from a field of more than 150 nominees. Criteria for the award included teaching experience, experience in directing research, honor society memberships, sponsorships of student organizations and scholastic fraternities, professional society memberships, listings in biographical works, community projects, lectureships, awards, and receipt of research grants-in-aid. Pauline's life work is summed up in these criteria. In addition to the hand-illumined certificate, the award included a $1,000.00 honorarium. Pauline gave her award money to the Research Foundation in Household Arts and Sciences at TWU. TWU's News Bureau kept Pauline's first university, Penn State, informed. Former friends and colleagues at Penn State were also able to keep abreast of Dr. Mack's latest honor in the *Centre Daily Times*. TWU, in its press release, highlighted the fact that Pauline's research projects in nutrition and textile technology had been supported by special appropriations and grants-in-aid totaling more than 3.5 million dollars. Also noted was Pauline's inclusion in *American Men of Science*.

A significant milestone and growth for TSCW. President Guinn saw one of his goals realized on June 1, 1953 when TSCW conferred its first two Ph.D. degrees. Alice Knapper Milson and Mae Yoder Moore, who had started their graduate work under Pauline's direction at Penn State, were the recipients. They had transferred to TSCW when Pauline came to Texas. Their course and research work were completed in the College of Household Arts and Sciences through a program totally funded by grants-in-aid provided by industry and foundations. By the first half of the 1960s, the number of

doctoral degrees conferred had risen dramatically, as had the number of bachelor's and master's degrees.

Dr. Guinn had also brought Pauline to Texas to help stem the decline in enrollment. L. L. LaRue, known as LaRue, came to TWU in 1949 as Chief Accountant and attained the position of Vice President for Fiscal Affairs. His 25 years at TWU closely parallels Dr. Mack's time there. We discussed Pauline's hiring. LaRue didn't know how Dr. Guinn got Dr. Mack, but the visionary Dr. Guinn probably perceived that Pauline was #1 in the country in her field. Enrollment at TWU had bloomed during WWII, when there was a dearth of men in co-educational schools. When LaRue came on board, enrollment was declining and people were ready to abandon ship. Total enrollments had declined from a high of 6,807 in the 1938-1939 school year to 5,129 in 1950-1951. When the crew came from Penn State, they got the ball rolling. They hit the ground running and didn't let up. The results began to show in the enrollment statistics. Bottoming out at 4,687 in 1953-1954, enrollment began to steadily increase. In 1959-1960, total student enrollments were 7,165. Dr. Guinn declared in May 1959 that TWU offered unique advantages to ambitious students whom it was attracting in ever increasing numbers. His message (TWU at Denton, 1959) at this time had evolved from that of the first president of the University:

> The aim of Texas Woman's University is to provide superior educational opportunities for its students in an environment adapted to their distinctive requirements as women destined for the important responsibilities of living as well as leadership in a society growing daily more complex.

Dr. Guinn's success in persuading Pauline to come to Texas helped him achieve this aim. LaRue, stating that Pauline was a great lady, no question, emphasized that she would tackle anybody and wouldn't let up. They took her to Austin numerous times to deal with the legislators. She was highly successful in demonstrating to them what people could do. LaRue noted, "That's where you get your money. She had delivered. You don't live on your reputation. If you are able and stable, your reputation keeps working." The growing enrollment was evidence that Pauline was getting the job done.

LaRue and Pauline became good friends. In all the years he knew her, Pauline never demonstrated interest in another romantic relationship. Undoubtedly, Pauline and Warren had loved each other. LaRue still remembered seeing them hold hands. LaRue also recalled that Pauline was certainly not inhibited. On one occasion, Pauline noticed moisture and condensation during a flight. She began yelling that the plane was on fire! On another occasion, she took out her false teeth to clean them and dropped them under the seat. She needed help getting them out. LaRue did not find Pauline difficult to work with and was cognizant that she was a great asset for the University. He also appreciated the use of the "computer" with the plug-in wires that Pauline brought with her to do his payroll.

Graduate student relationships. Pauline's relationships with her graduate students in Texas were sometimes conflicted and teetered on the fulcrum of a love/hate continuum. Dr. Mack was normally very nice to students, except for when it came to writing theses and dissertations. Apparently, Dr. Mack had written into her contract as part of her agreement to come to TWU that all of her students' theses and dissertations would be submitted in her specified format. Dr. Mack demanded excellence. Foreign

students, in particular, had difficulty with English grammar. Dr. Mack would scribble all over the papers, wanting rewrites. She was adept at grammar and could sit down and write for hours, cutting, pasting, editing, and so on. She would do it ad infinitum. Jessie Ashby said that Dr. Mack and her students would go round and round about it. The ones who hated her still respected her. Love or hate… Jessie Ashby pointed out that all of Dr. Mack's graduate students revered her when they got through, but they could have cut her head off when they were working under her. By the end of their projects, students would be thankful that Dr. Mack was so capable. However, she would tax their patience in between! Eccentric, prone to doing things her way, kind, and loyal, Dr. Mack did have some students whose personalities clashed with hers. Jessie noted that if one or two of them were reincarnated, they would still feel the urge to kill her.

Gertrude Adams Lathrop was perhaps the second graduate student to live with Dr. Mack in Texas. Mae Yoder Moore, from Pennsylvania, lived with Pauline during that first year in Texas until she graduated and returned home. World War II had altered the course of Gertrude's life. With romance out the window, she had to work. Employed as a lab assistant and then development chemist, she lost her job when the men came home at the end of the war. Her next step was to find a graduate assistantship and head back to college. She sent letters and resumes to Penn State and Dr. Mack, who was at the Ellen H. Richards Institute. Gertrude applied to study with Dr. Mack because she had the world's record when it came to reputation. She was unique and concerned with education and the improvement of women. Gertrude's college advisor wanted her to go to Penn State for these reasons, but no response came for quite some time.

Gertrude finally received a call to meet Dr. Mack in a hospital lobby in Philadelphia. Warren, hospitalized there after a heart attack, was in critical condition. Pauline Beery Mack told Gertrude she needed calculus in summer school to receive a research fellowship sponsored by American Viscose Corporation. Gertrude went to NYU and passed calculus, but hadn't heard anything more from Dr. Mack. On September 10, 1952, she received a night letter delivered by Western Union. The letter asked why she wasn't in graduate school and said if she didn't report by September 15 she would forfeit her scholarship. It was signed by Pauline Beery Mack, Texas State College for Women, Denton, Texas. Gertrude didn't know that Warren had died and Pauline had moved. She also knew nothing about TSCW. Going on faith, she packed, partied, and arrived with a hangover in Texas.

Gertrude's first view of campus was the Pioneer Woman statue. She dropped her suitcases, read the inscription, and determined that if all of those women in Texas could make the grade, so could she. After meeting with Dr. Mack, Dr. Mack asked her to live with her. Gertrude was unaware that Pauline cared less about housekeeping and cooking to the point of not being able to boil water! Pauline needed companionship and security. She had taken on an ambitious agenda in Texas and no longer had her helpmate in life. Dr. Mack, who researched food, clothing, and shelter, had never taken care of these items on a personal basis.

Gertrude was burdened with her graduate work, home duties, and Pauline's rigorous schedule. Pauline, lonely and feeling uncared for, buried herself in her work. Gertrude, ever the problem solver, addressed the issues during the holidays by planning a surprise party at Pauline's house. Pauline was astounded when she came home and nearly

85 people, who had sampled the spiked punch, yelled “Happy Birthday.” For the first time, Gertrude saw her laugh. Over time, Pauline began enjoying life again, celebrating birthdays and everything else.

Gertrude’s remaining time with Dr. Mack was not easy. Pauline was not cognizant that Gertrude found her needs and controlling ways to be sapping her energies. When Gertrude decided to accept a job back East and told Pauline, it was akin to a tornado hitting. Gertrude figured that Pauline, like other brilliant people, was not a normal person in many respects. One can manage if you deal with them accordingly. Though she and Pauline had both happy and sad times, it was not the life Gertrude desired in her own ambition and drive. Though she tried to forget this part of her life, Gertrude maintained an affection and respect for Dr. Mack. They stayed in contact until perhaps the 1960s.

Esther Broome credits Pauline for many of her successes at TWU in the textile field because she taught her so much. Upset about finding roaches in the room the University had assigned her on Austin Street, Esther called Dr. Mack. Dr. Mack invited her to move in with her in exchange for driving her places and preparing lunch. Dr. Mack promised to help her with her dissertation. Esther accepted and stayed from September 1959 until January 1962. Dr. Mack kept her promise, working with Esther at night when everyone else was gone.

Esther found that Dr. Mack never had any money in spite of her income. She gave it away, frequently to students. If Dr. Mack was on your side, she would spend any amount of money and work hours to help you. Dr. Mack did not have any close friends, other than her students, to Esther’s knowledge. However, Esther thought she had lots of

students who really loved her. Though very kind, she was also gruff and could scare you to death. Esther was able to handle that part of it, as Dr. Mack was not gruff with her when she lived there. Esther thought that Dr. Mack and Gertrude Lathrop had frequent battles, but her relationship with Dr. Mack was very pleasant. Together they watched *As the World Turns*. They also attended tennis matches and golf tournaments. Many of the faculty on campus laughed at Dr. Mack, and on occasion, would pity Esther for living with her. Esther felt that they were envious because Dr. Mack had such a good mind. Dr. Mack was able to do anything she set out to do, getting it done one way or another. Her influence was great throughout Texas.

Esther appreciated what Dr. Mack did, but was glad when the opportunity came to have a place of her own. Mary Sue Farrar approached Esther about moving in with Dr. Mack. Esther had been looking to buy a home and hadn't found one yet, so she moved in with a friend and Mary Sue moved in with Dr. Mack. Dr. Mack advocated for Mary Sue and did much to help her succeed academically. Though Mary Sue made it through her bachelor's degree and master's degree, the Ph.D. was daunting and not to be. Esther remembers Dr. Mack attending statistics class with Mary Sue and then teaching it to her again when they got home.

Dr. Betty Alford met Dr. Mack through a party she held for students at her home. Betty was an undergraduate at the time and Pauline was her major professor for her master's program. Betty found Pauline to be a very strong individual with a controlling nature, characterizing her as such a wonderful woman and such a difficult woman. Dr. Mack generously gave to causes, helped her students, and would take them to lunch. She had the rare ability to charm anyone she chose to charm. However, her controlling

nature could make it difficult for a student. For instance, Dr. Mack's hospitalization in the 1960s caused a furor when she had someone gather her students' work from her office. She locked their papers in a closet at the hospital so the students couldn't work on them without her supervision. There were no copy machines at the time and students who didn't make carbon copies trusted their advisors would return their work after checking it. The dean intervened and the students were able to complete their work so they could graduate on time. Betty speculated that Pauline did not want her to finish and leave. Prior to wrapping up her dissertation, Betty chose not to confide in Pauline that she was pregnant for fear that this information would interfere with receiving her Ph.D. Pauline's response when she finally heard the news from Betty was, "How did you have time to get pregnant while doing this?"

Betty Alford would end up working for Pauline for many years. During this time she would on occasion succumb to Pauline's influence, agreeing to do work and projects that she really didn't want to do. One such task involved getting Pauline's graduate students back on track. While being conflicted in her feelings toward Pauline, Betty admired her greatly. Pauline altered her views of what women could do, changing her life. She was a major influence on Betty, who learned to be a feminist in a gender-free way in the workplace. Dr. Mack's perspective was that we do this job well irrespective of whether we are male or female. Betty's sons learned this at home and one has passed this perspective on to his three daughters. Betty saw that Pauline helped many students and staff members, though mentoring was not a term used at that time. Pauline believed the job was to help people move on with their lives. She would have called it teaching them what to do. Pauline was a hard person not to like, yet some did really dislike her. There

was no iffy about it! However, Dr. Mack was not bothered by the perspectives of others. As Betty indicated, you can't make the kind of changes Pauline made and please people.

Pauline also generated conversation among her students, colleagues, and community for some of her unique behaviors. She was perpetually cold and wore a full length mink in winter and a mink stole in the summer. After a fall at Love Field Airport, she began wearing tennis shoes for stability, along with the mink. This was during a time when tennis shoes were only worn for sports. Pauline would trek across campus in her mink and tennis shoes, carrying her work papers in a picnic-style woven basket. Elizabeth Snapp, retired from her position as Director of Libraries at TWU, can still visualize Pauline in her unique attire walking purposefully up and down the sidewalks on the southern end of campus. Elizabeth also frequented the same beauty parlor as Pauline, often seeing her there during her monthly visits. Pauline was typically very quiet and didn't encourage idle chatter. The infamous mink, having been worn for years, hung on a coat stand near the door and provided an olfactory clue that Pauline was there to get her hair done.

The Launch of a Second Texas Decade

The United States was less than joyful when the Soviet Union launched the first artificial satellite in history on October 4, 1957. Launching the beach ball-sized Sputnik I signaled the arrival of the space age, brought by our seemingly technologically superior Cold War rival. With it came new developments in the realms of politics, military, technology, and science. The launch of the satellite that weighed 183.9 pounds was also directly responsible for the creation of the National Aeronautics and Space Administration (NASA). Congress passed the National Aeronautics and Space Act in

July 1958, which established NASA as of October 1, 1958 from other agencies. One could hardly expect the indefatigable Dr. Pauline Mack to miss out on the hustle and bustle of the space race to follow, let alone fail to see the opportunities of the space age.

Civil defense. Denton shared a unique distinction during this era, home to a U.S. Army Nike missile base and also the headquarters for the Office of Civil and Defense Mobilization for Region 5. Region 5 encompassed Texas, Oklahoma, Arkansas, Louisiana, and New Mexico. Defense against potential enemy attacks and civilian defense in case of an attack were prominent focal points of the country's defense. In the fall of 1960 the Army extended its Operation Understanding to include women. Twelve North Texas women were invited by the U.S. Army Air Defense Command to tour its centers in Texas, New Mexico, and Colorado. The intent of the tour was to give the public a better understanding of the Army's nationwide air defense organization through distaff community leaders. Wondering what distaff meant, I checked it out: women's concerns, a literary term sometimes considered offensive. Perhaps it's a positive indicator that nearly fifty years later I had no recognition of the word!

A year before she turned 70, Pauline was one of the twelve women who toured Fort Bliss in El Paso, McGregor and White Sands Missile Ranges in New Mexico, and the headquarters of the U.S. Army Air Defense Command and the United States Air Force Academy in Colorado Springs, Colorado. The group flew on a military aircraft. Pauline was requested to share the details of the operation because of local interest in the defense system about which the group had been instructed. In addition to presenting the general idea of the Air Defense system after the trip, Pauline also confessed that she slept

better now that she had seen the details of the systems. Operation Understanding had instilled confidence in the participants.

Retirement, sort of. Pauline's expertise and productivity would be recognized in some unique ways in the latter portion of her career. She kicked off the 1960s with an invitation to join the staff of Excerpta Medica, an international medical abstracting service headquartered in Amsterdam, Holland. The organization wanted Pauline to cover medical/nutrition research literature of her choosing that was published in English-speaking nations. At the same time, a problematic situation regarding her relationship with TWU was an omnipresent cloud over Pauline's head.

Dr. Pauline Beery Mack's 70th birthday on December 19, 1961 was a touchy subject, and not for vanity's sake. Retirement rules meant that Pauline could no longer be on the University payroll. That little requirement didn't stymie Pauline for long. In the official 1962 press release, Dr. Guinn noted that her retirement as dean of the TWU College of Household Arts and Sciences was due to the fact that it was impossible to keep on with this role and also devote her full energy to research, which was broadening. Dr. Guinn acknowledged that the loss of Dr. Mack's services in academic administration would be keenly felt. He stated that he was deeply gratified to know she would have more time to devote to further development of the various research enterprises that had brought both Pauline and the University wide acclaim. While this was the official line, reliable sources noted that Pauline's ongoing directorship of the Research Foundation could be supported through granted research funds and not the official payroll. Pauline had figured out a way to forge ahead with her work. With a decade of interesting and highly valuable work to come, Pauline was still very much an asset to TWU.

Dr. Jessie Bateman succeeded Pauline as dean of the College of Household Arts and Sciences. Dr. Bateman spent her first year in the role focusing on curriculum. One of the changes she initiated was to move the sophomore course on family living to the freshman year. She did this to benefit the girls who withdrew from school after their freshman year in order to get married. Dr. Bateman's greatest administrative challenge at that time was to locate qualified faculty members to teach courses in nutrition and child development.

In March 1962, while Pauline's "retirement" was being crafted, Pauline marked her first decade in Texas at a special event. Pauline reviewed the decade of research at the Alumnae Association Board luncheon. Nearly ten years had elapsed since she had outlined the new research program to a Homecoming alumnae group. On this occasion, Pauline was introduced by one of her former students and a former president of the TWU Alumnae Association, Dr. Kate Adele Hill. Dr. Hill had received her Ph.D. in 1957. Pauline spoke of the research that needed no particular financial support and that which necessitated financial support and highly technical equipment. During the presentation, Pauline used colored slides to illustrate the more technical aspects of her talk. She discussed a wide range of textile and nutrition research. In the area of textiles, Pauline spoke of the Cotton Research Committee of Texas and the involvement of three other Texas schools in their cotton research program. Each of these schools specialized in a particular area. TWU found a unique niche in converting cotton yarn into cloth to further the understanding of the legislature and public about the research program and its financial implications for Texas. TWU was the only school in the country at that time that had its own laundry and dry cleaning plant as part of its research program.

Pauline spoke on many research projects, but one in particular drew my attention because of the poignant headlines that appear every so often about a young, seemingly healthy athlete who dies while participating in a sport. She was talking about a simple step test that was used to measure fatigue that was sometimes given to the children in the TWU nursery school. That led her to reflecting on the findings that sometimes college football players did not possess enough fatigue resistance to pass the test. She advocated for periodic electrocardiograms, as research tests showed that many children have faulty hearts and should never have played football. Football intrigued Pauline for other reasons as well. Helen Ludeman recalls them going to watch a Penn State game at the Cotton Bowl. Pauline observed that many of the players had large necks, which then led to a new research idea. Pauline wanted to find out what type of diets caused that and afterwards she pursued that question. In Helen's mind, another reason why Pauline came to Texas was Pauline's openness to jump into things that she could use.

Cholesterol. I'm a tad cranky this morning, missing my morning coffee. Why? I'm fasting in order to get my serum cholesterol levels checked. Cholesterol was also on Pauline's mind in 1962. The Research Institute at TWU was involved in various nutritional studies. Some of these involved research on cotton and cotton products. TWU conducted research for the Cotton Research Committee of Texas, an agency of the Texas State Government, who supported the research at TWU and other Texas universities. One of the studies was on the effect of cottonseed oil on the nutritional status of subjects age 55 and older. Pauline submitted a proposal to the Cotton Research Committee to investigate how cottonseed oils lowered blood cholesterol. The Committee sent her proposal to the National Cottonseed Products Association for review. Feedback on the

proposal noted that the real problem at hand was to demonstrate that reducing blood cholesterol would lead to better health and fewer coronary disorders. The reviewer pointed out that statisticians would recommend a controlled study with a very large number of participants from varied age groups and occupations. A possible alternative was suggested to resolve the controversy- determine whether cholesterol left the body or if it was deposited in certain organs and tissues.

Much research has been done since Pauline's time to determine the efficacy of lowering serum cholesterol. Drugs such as Lipitor have been shown to reduce serum cholesterol levels, lowering LDL and triglycerides while raising HDL. Lipitor, backed by over 15 years of research, has been studied in excess of 400 ongoing and completed studies involving over 80,000 patients. That early question appears to have been possibly somewhat resolved, as Lipitor has been shown to reduce the risk of heart attacks, strokes, some types of heart surgeries, and chest pain in patients with a number of common risk factors for heart disease.

Wetzel Grid. Wrinkling my nose at the antiseptic smell, I craned my neck to see the marks Dr. Charles was making on a chart that looked like something from an advanced math class. My son was a preemie and I was anxious for reassurance that he was having the necessary growth. I didn't quite understand the chart at the time, but all was well and he is now six foot four. Reading a letter that Norman Wetzel, M.D. wrote to Professor Mack in October 1962 not only brought back those memories, but also clarified the design and function of the chart. Dr. Wetzel was a prominent pediatrician who had authored the Wetzel Grid. The Grid was designed to take into account the uniqueness of individual children. One of its three parts was arranged into nine diagonal channels, each

of which represented one of nine general body types ranging from the very obese on one end to the very thin on the other end. A child's weight and height were used to locate a child in a channel. If the child remained healthy, she stayed in the channel in which she was located at birth. A second part of the Grid had five channels that indicated the rate at which a child was growing. The speed of development was calculated from age and size determined from the first section of the Grid. In the event of growth failure, calorie deficiency could be a causal factor. The third part of the Grid is where one could determine the calorie deficiency or the appropriate caloric intake for a child. The chart allowed the detection of a clinical defect before it became readily apparent. The Wetzel Grid was developed on theoretic grounds as opposed to being a statistical description of a population. Though it has been shown to be valid for any population or species, it never gained popularity or widespread use.

Dr. Wetzel contacted Pauline for two reasons. He had read a paper of hers in the *American Journal of Clinical Nutrition* that described her studies of lysine-supplemented diets in pre-adolescent children. He was considerably pleased to learn that Pauline was still using the Grid technique in her clinical studies and expressed his frustrations:

> Oddly enough, I have had to deal for a number of years almost more with papers that ignored, or were even openly opposed, to the method I have advocated for so long. At times I have even reached the point of some noticeable discouragement; so much so, in fact, as to go through what Dulles called an "agonizing reappraisal" of Grid principles and the advantages that flow from them, more specifically, the importance of studying the independent relations of body size and physique rather than the entangling influences between height and weight. What a

> relief it was, for once, to be able to go through results such as yours without the ambiguous and, I must say, often zany reliance on percentile heights and weights as though these, by some magic, contain more information than the original data themselves!

The other stated reason for which Dr. Wetzel wrote to Pauline was to tell her that he had missed seeing reports of hers in the past few years, probably because he had not been looking in the correct places. Seeing this made me wonder about the veracity of some thought among Pauline's staff that she had made an enemy or two in the wrong places and had stopped publishing in juried publications.

Special visitors. March 31, 1964 found the TWU campus in the spotlight. Mrs. Lyndon B. Johnson, known as Lady Bird, arrived on campus with her Secret Service escorts. Also visiting were Texas' first couple, Mr. and Mrs. Connally. Mr. Connally was recovering from an arm wound received during the assassination of President Kennedy. When someone on campus commented on how well Mr. Connally was looking, Mrs. Connally responded that he was supposed to be wearing a cast, but he was ornery! Lady Bird Johnson was there to receive an honorary doctorate of laws. During her whirlwind tour on campus, President Johnson's wife visited Dr. Mack's research center.

Pauline's research domain was located on the top two floors of the oldest academic building on the TWU campus. Claire Eyrich of the *Star-Telegram* (1963) noted that this mysterious electronic realm was presided over by a small, articulate woman who was one of the most respected research scientists in the country. Dr. Mack's low, deliberate speech and animated, glowing dark eyes caught the reporter's attention, as did Warren Mack's engravings hung on Pauline's office wall. To get to Pauline's domain,

one had to travel by slow elevator or flights of well-worn iron-railed stairs. It is not clear which route Lady Bird Johnson and her entourage chose, though many individuals that day were highly impressed with her physical endurance and pace.

During Lady Bird Johnson's visit, Dr. Mack took the opportunity to explain the NASA research she was engaged in for the purpose of learning more about probable astronaut calcium loss during future Gemini space flights. Having done her homework, Lady Bird Johnson replied, "Yes, Dr. Mack, I've been hearing about you… Congratulations. I think it must be thrilling" (Brinkerhoff, 1964). While George Vose had his picture taken with Lady Bird Johnson and Dr. Mack, the Secret Service would not allow her to enter his office. Since George's office had one door, there was only one way out. In her Christmas 1964 letter, which detailed enough work to make one wonder how Pauline managed before retiring as dean, Pauline wrote of Mrs. Lyndon B. Johnson's visit to TWU. Pauline declared that Mrs. Johnson had proven to be charming and they had all fallen in love with her. This was particularly true for the five men engaged in a 30-day bed rest immobilization study. Mrs. Johnson had complemented each of the men for their devotion to the space effort of the United States.

Nostalgia. Pauline's 1964 Christmas letter provides a glimpse of her reflections on earlier days. More than a dozen years had passed since Warren's death and her relocation to Texas. Pauline shared her feelings and her sustaining optimism in the portent of Spring:

> When I began this letter on December sixth, the many red oak trees which Warren had selected for our grounds, but which I had planted after he passed away were blood red. The pecan trees and the older native oaks had lost most of their leaves,

but the gum trees and the aspens were brilliant yellow and the woods round about were lovely, even though the trees are smaller here than in Pennsylvania. When I was in Princeton in October the color was at its height and a great wave of nostalgia came over me remembering the fall color which Warren and I enjoyed together.

As December has progressed, with one freeze, most of the leaves have fallen except those on some of the red oaks. But here, little more than two and one-half months will go by until the new leaf buds will push the remaining leaves off and Spring will come.

The combination of her birthday, the Christmas holidays, her wedding anniversary, and the anniversary of her mother's death proved to be a difficult time for Pauline. Jessie Ashby found that Dr. Mack would become sad and hard to get along with for a few days every year in December. Dr. Mack would expect others to maintain the same hectic work pace during the holidays. In order to keep Dr. Mack from planning research projects over the holidays, Betty and Joe Alford began inviting her to holiday family dinners. Betty's parents really liked Pauline. Her ability to converse with people on topics they were interested in endeared her to many. Pauline's love of jokes and Betty's father's substantial repertoire from his travelling salesman days made for some humorous occasions. Pauline would talk a lot about Warren, remembering how he had planned her wardrobe for her speaking engagements and their 25th anniversary celebration. Her respect and caring for her husband were very evident. Joe Alford's sentiments toward Dr. Mack were conflicted. Though Pauline was perceived as more respectful of the Alfords after Betty completed her doctorate, Pauline's intrusiveness on

their private life left its mark. Pauline also spent a lot of time with Helen Ludeman's father prior to his death, enjoying her visits with him and their conversations. While not a college-educated man, Helen's father did a great deal of reading.

Getting in bed with NASA. The NASA research that Pauline had discussed with Lady Bird Johnson had begun with the foresight to connect the nutrition and bone density research taking place at TWU with the issues of calcium loss during manned space flights. Though Pauline's life's work up to this point made TWU a viable candidate for research on calcium loss, the opportunity was nearly missed. One of TWU's regents serendipitously noticed that NASA had hired a firm to screen 10 colleges and universities in Texas, Louisiana, and Oklahoma as potential researchers for the study. Pauline didn't mince her words on this as she sniffed: "They must have thought we were nothing but a girls' finishing school up here; we weren't even on the list" (Harris, 1963). The issue was addressed with NASA and she obtained the opportunity to submit proposals for the project. An appearance in Washington sold TWU's program of measuring calcium density through X-rays and led to the first contract with NASA for a bed rest study. When Pauline was questioned about whether she would personally participate in the tests, she retorted: "This is my project. I will handle it. This is my life's work" (Harris). While Harris noted that Dr. Mack was dowdy and preoccupied as one would expect of a dedicated scientist, he also noted that when Pauline gave a tour of the laboratories she was dressed in red from head to toe, including her hat adorned with red artificial roses. At 71 years of age, Pauline was chomping at the bit to, as Harris put it, "tackle the question of what space is doing to her precious bones, and to prove in the doing that TWU is much more than a girls' finishing school."

NASA issued a two-year contract for ~$89,000.00 for the study of calcium loss of men on space flights. Pauline was named principal investigator of the studies. Assistant Professor George Vose and Dr. Ralph E. Pyke were the co-investigators. NASA research workers had already found significant calcium loss from the bodies of men in actual orbital flight and in simulated flight situations. The NASA researchers had not determined which skeletal parts the calcium came from, so the TWU studies were designed to determine the answer. Baseline studies on men and primates would determine skeletal density in various parts of the body at complete rest for a variety of periods. TWU would also cooperate in radiographic bone densitometry in the Manned Space Metabolic studies conducted by NASA in Houston. TWU's work would also be integrated into the In-flight Primate Studies which were centered in California at Moffett Field. Primates were being readied for a 24- to 30-day orbital flight. Eight scientists from around the country, including Pauline, were cooperatively involved in this work.

TWU received a second grant of ~$16,000.00 at the end of 1963 to participate in biosatellite research to study the effects of space flights on monkeys. Some of the monkeys sent into orbit would be restrained. Others would be permitted to run around in something akin to a squirrel cage. Pauline and George Vose would travel to Moffett Field to take X-rays of the primates. The X-rays were brought back to TWU for bone density and calcium concentration measurements. The technique for measuring bone density that was developed by Pauline and her colleagues was viewed as a highly accurate method to measure the quantity of mineral in living humans and experimental animals. Monkeys would also be used in the studies at Denton. Pauline noted in May 1963 that she was keeping one in her home bathroom, where it was living the life of Riley. George Vose

was not aware that Dr. Mack kept one of these not-too friendly animals at home, but Betty Alford remembered it being housed in the room above the garage that was to have been Warren's studio. A staff member came to feed it. Apparently there were issues of hygiene and escape, so the monkey ended up in the old post office building on campus that was converted for use as a monkey home. Of course, this was before the advent of rules on animal care.

George Vose was involved with Dr. Mack early in the biosatellite program. They made frequent trips to Moffett Air Force Base for program updates. Behind the Old Main Research Building on the TWU campus was the small abandoned post office building. Some chimpanzees were caged there during the research program. TWU was involved in the testing, selection, and preparation of Primate 470, known as Bonnie. Bonnie was a male Macaca Nemestrina, or pigtail monkey. Bonnie was featured in a CBS movie entitled *The Animal World*. Dr. Mack had a cameo appearance in the movie, shown X-raying Bonnie immediately before his June 28, 1969 launch. Bonnie became grossly pathological and unresponsive on the ninth day of the flight, which was terminated. He died 8 hours after mission recovery from ventricular fibrillation. While the intent was to send primates into space to ensure that space flight was safe for humans, George noted that it almost turned out to be the other way around- men went into space without waiting for biosatellite information and the program eventually faded away. Animal research was discontinued at TWU when the Gemini space program began.

During this era of interest in space, Pauline's gender did not escape notice. Walter Moore of the Texas Almanac pointed out that Dr. Mack was among the first of her sex to plunge into space, though mentally and not physically. Moore (1963) noted the

brain power and scientific dedication that had led to Pauline's involvement in the space effort. In writing of Pauline's quiet, bordering on brooding manner, he referred to her frank and fearless speech that never failed to impress her audience. In a thoughtful reflection, Moore recalled one of Pauline's first presentations when she came to Texas in 1952. Pauline's lack of pretense and attire caused some officials of the Texas Agricultural Workers Association to question whether they erred in inviting Pauline to speak before their professional group. The critical audience was charmed by Pauline's masterful, scientific presentation. A decade later, Pauline still impressed others with the strength of her ability and vision. Moore pointed out that one only had to spend a few minutes with Pauline to extinguish any thought that she had retired her probing, productive mind. Cognizant that Pauline was nearly 72 years of age, Moore acknowledged that the woman who was born before the Wright brothers flew was now expected to contribute much to the effort to send American men into space. Two years later, writer Bob Kerr, addressing Pauline's and TWU's involvement in the space program, would also draw attention to gender by pointing out that space was not strictly a man's game.

"Anybody who thinks you can take it easy in the South is crazy" (Engleman, 1964). Pauline was smiling at Reporter Engleman from behind her cluttered desk at TWU. At work since 1:00 a.m. following four hours of sleep, Pauline was wearing a fur-collared suit and her Phi Beta Kappa Key on a long gold chain. Engleman was reporting on the space studies taking place at TWU. He seemed to have quickly captured Pauline's complexities, noting that she was a woman who obviously could charm, or if necessary, scare, the hair off a jackrabbit. Engleman declared that Pauline could smile like a West Texas sunset one minute and snap like a mouse trap the next. A remarkable woman,

Pauline was at the center of what Engleman termed the most significant research projects to ever take place in Denton. The Denton Chamber of Commerce, in acknowledgment of Pauline's professional accomplishments that helped to make Denton better, presented her with the 1964 Otis L. Fowler Award. Her community valued her. Pauline understood the importance of community, as Betty Alford pointed out, and the importance of people in supporting one's endeavors.

By June 1964, TWU had received ~$200,000.00 in NASA grants. Following six 14-day studies, five healthy young males were now on 30-day immobilization rest. The 14-day studies were completed in preparation for Gemini flights, with associated diets undergoing evaluation. The 30-day trials were geared to longer space flights, such as the Apollo or moon flights that were to take place in the future. It must have been an amazing time on the third floor, where Dr. Mack's "guinea pigs" were confined.

In a description of one of the 14-day studies, volunteers were ordered to not even bat their eyelashes unnecessarily. Wallace Bruce, a 33-year-old retired Air Force sergeant participating for the second time, pointed out that the first three days were the most difficult. After that, one sort of got used to feeling helpless, sometimes even feeling like an infant. Orderlies attended to the recruits' needs that would typically require movement, including brushing their teeth for them and bathing them. Subjects were carried on litters to another room for daily X-rays to check bone density. Results of the studies to date showed that the level of dietary calcium intake prior to and during a period of bed rest immobilization was a key factor for predicting skeletal calcium losses. The recruits were being fed experimental diets to determine if calcium loss could be solved this way. Dietitians who prepared the meals spoon fed the participants.

Returning to the original question of which part of the skeleton was most likely to lose calcium, X-rays were taken of the foot, knee, hand, and back. The intent was to tailor exercises to the part of the body that was found to be most susceptible to mineral loss to increase mineral retention in the bones. Input and excreta were also analyzed to determine whether or not mineral output was in excess of intake.

Despite Pauline's contributions to the study of bone density and the NASA studies, she would be thwarted by her gender. On several occasions, the principal investigator for the studies would miss out on a key experience. The Gemini-7 mission is one of many that illustrate the circumstances. Pauline and X-ray technician Bill Stover had taken three sets of X-rays of Astronauts Frank Borman and James Lovell at Cape Kennedy during a two-week period before the Gemini-7 launching on December 4, 1965. George Vose was on board the carrier Wasp to take X-rays of the astronauts immediately after recovery. Dr. Fred Vogt was on standby in Hawaii, in case the target landing area was missed. Dr. Pauline Gracia Beery Mack was not on board. The reason for the absence of the principal investigator was clearly an issue of gender, as noted by Dr. Paul Lachance. A staff member of the Manned Spacecraft Center in Houston, Dr. Lachance had inherited the pre- and post-flight bone studies emerging from TWU. He quickly needed to know a great deal of information about calcium in the diet, along with many physiological issues pertaining to space flight. Dr. Lachance recounted his monitoring of the research in a 2006 oral history project. In discussing the team he had on the carrier, he acknowledged that co-investigator George Vose was the X-ray person because they wouldn't let Principle Investigator Dr. Mack on because she was a woman. In those days it was against Navy rules. Dr. Lachance said they went to Boston to visit

the ship, but Pauline could not go with the trip. “Anyway, that’s neither here nor there. It’s just some of these incidences.” While Dr. Lachance held that viewpoint, it is doubtful that Pauline shared it. Dr. Lachance verified that results indicated bone loss and muscle loss that remain problems to this day. He noted that original papers are no longer cited, as everyone cites the most recent ones. “But that’s the penalty of science,” he mused.

Figure 14. X-ray from bone density studies. Photo courtesy of The Women’s Collection, TWU.

Dr. Betty Alford was at the Hotel Texas on March 18, 1966 as a closing session speaker for the Texas Dietetic Association’s state convention. Dr. Alford was three years into her work with Pauline at TWU, studying the effects of prolonged inactivity on calcium metabolism and certain effects of space flight. Dr. Alford spoke of the notable findings in the study of calcium loss in space flight that bone mass was rapidly recovered when subjects became ambulatory again.

Pauline addressed the Denton Rotary Club on May 4, 1967. In her talk, she noted that TWU was beginning its 12th bed rest program. She informed the attendees that while NASA handled the diet program, TWU did all the computations on food values. Pauline proclaimed that TWU was the first in the country to computerize diets. In discussing an issue that would be highly sensitive today, Pauline acknowledged that some of the

monkeys from TWU's primate center were sometimes sacrificed after bed rest studies to obtain more detailed skeletal studies. Monkeys were used because their metabolic processes were similar to that of humans. Pauline also confided to the Rotarians that it was difficult to get a monkey into bed. She told the Rotarians that "they could cooperate if they wanted to, but they never want to" (Moon, 1967, p. 2).

Journal articles pertaining to the studies appeared in 1967. Pauline, Paul Lachance, George Vose, and Fred Vogt coauthored one on bone demineralization of foot and hand of Gemini-Titan IV, V and VII astronauts during orbital flight. The article was published in *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*. Pauline and Paul Lachance coauthored another article on the effects of recumbency and space flight on bone density that was published in *The American Journal of Clinical Nutrition*. In the midst of all the space excitement, Pauline took time to co-present with Dr. Esther Broome at the morning sessions of a four-day course in home laundry care. The courses took place the week of October 22, 1967 at four different theater locations. "Taking the blues out of washday" was sponsored by the Times Herald. The following year, a paper by Pauline and Dr. Sidney O. Brown was presented at the meeting of the Texas Association for Radiation Research in Austin. The topic of this research paper, presented on November 20, 1968, was the effect of Cobalt-60 radiation on the growth and bone density of rats.

Shortly after she turned 77, Pauline was on hand for the December 21, 1968 launching of Apollo 8. X-rays of astronauts Frank Borman, James Lovell, and William Anders had been taken at various intervals before the launch. Dr. Mack said that the launch was the most fantastic happening one could hope to see. Lovell, Borman, and

Anders circled the moon on this mission, a significant first for the space program. Pauline did not have the opportunity to see their Pacific Ocean recovery. Bill Stover was on the USS Yorktown, unimpeded by his gender, to take the requisite X-rays. The bed rest studies preceding the flight incorporated the use of an exercise instrument during horizontal inactivity. The results showed a decrease in skeletal mineral loss, so the recommendation was made for the Apollo astronauts to use the equipment for relaxation.

Figure 15. Dr. Pauline Mack, second from the right, with members of the TWU group who conducted bone density studies for NASA. Photo courtesy of The Women's Collection, TWU.

In reflecting on his years with Dr. Mack, Bill Stover noted that you could cross Dr. Mack and engage in a verbal battle, but you had better be right or she would never let you forget it. If you were right, she would congratulate you. She enjoyed a good battle. Dr. Mack, constantly assailed by those who didn't believe in their work and didn't believe in how good she and her staff were, was successful in defending her techniques. This might have been in Washington, or on her home turf. On one occasion, Bill

disagreed with the exposure, or technique as it was known, involving the X-rays of monkeys. Bill would take half a day to convince her they couldn't do it and would show her by doing the X-rays. When he did it his way, she had him because the film didn't turn out right. Dr. Mack had a way of conning people into wanting to do something. Bill stated that if someone wanted you to dig a ditch and you didn't want to do it, by the time Dr. Mack was done talking to you, you wanted to go dig it. That skill is what enabled her to get so much accomplished. The grueling work schedule that Dr. Mack had in place led to complaints, which then led to the University's installation of a time clock.

Bill Stover also recalls Dr. Mack challenging Dr. Guinn, cussing as things got heated. He would reply, "Yes, ma'am," and hang up, with Dr. Mack getting what she was after. Bill had never met anyone quite like her. She was a chameleon, incredibly smart, and a most unforgettable character. A kind but demanding woman, she showed compassion. When one of her employees was having divorce and financial issues, she gave him an extra salary out of her pocket and never asked to be repaid. Typical of most employee-boss relationships, everyone would get mad at her. On the other hand, she had a way of making you like her, also. Bill thought that Dr. Mack liked males better than females, as they were less conniving. When questioned on that viewpoint, because Dr. Mack was female, Bill responded that she wasn't female. Dr. Mack viewed herself in whatever manner the occasion required.

As the 1960s were coming to an end, Pauline published an article on automated techniques in bone densitometry (Mack, 1969). The TWU Research Institute was engaged in complex animal experimentation with the Macaca Nemestrina, or pigtail monkey, as part of a cooperative endeavor with five other laboratories. The biosatellite

research involved a recoverable biological laboratory for a 15 lb. monkey that would be launched from Cape Kennedy. The data telemetered from the small spacecraft holding the tiny primate would provide answers to significant problems for future manned flights. In March of 1969, the 78-year-old Dr. Mack was a speaker at the district meeting of the Texas Home Demonstration Association at the Baker Hotel. In October 1969, Pauline provided the Denton County Chapter of the TWU Alumnae Association with a review of the research taking place at TWU. In preparation for the Apollo Application Program, eight men had just finished their involvement in a 56-day bed rest study. Data analysis from this study was expected to take several months. The alumnae also toured the bed-rest facilities and ate a diet akin to that used by the astronauts. The food had been preserved by a comparatively new and expensive process. At the same event, Pauline offered her opinion that if women used the knowledge they possessed or could obtain regarding how to feed their families, they would do a much better job than most of them were doing at the present. Education, Pauline emphasized, is the most important factor in improving nutritional status.

The 1970s, Pauline's 80s

Snoopy. It was 9:00 a.m. on Thursday, April 23, 1970. Pauline was in her work domain on the third floor of the College of Education Building. Francis M. Lucas, from the U.S. Navy Office of Naval Research, and Hiram D. Farrar, a Dallas representative from NASA, were on hand to present a special award to Pauline. Four Texas university scientists had been selected to win the Silver Snoopy award for their contributions to manned space flight. Pauline was one of the four to receive the award, which was rarely given to university staff members. The award was named for the registered emblem

designed by Charles Schulz, Snoopy the Astronaut, which was used for recognizing individuals who contributed professional excellence on a daily basis to the manned space program. A letter written by Astronaut James C. Lovell to Pauline was read at the presentation. It had been written on March 24, 1970, before the aborted Apollo 13 flight. His letter acknowledged Pauline's contributions and the hope that she would wear her Silver Snoopy with deserved pride:

> This letter is to express to you my personal appreciation for the care and effort you have demonstrated in performance of your duties on the Apollo Program, and especially for your contribution to the research of physiological effects upon astronauts in space. Your work on bed rest experiments and bone demineralization studies has been exemplary in all respects.

Lovell offered his congratulations and best wishes for continued achievement. The indefatigable Dr. Mack had the Apollo Applications work on deck. Still involved in professional publications, her journal article on radiographic measurements of changes in bone density was published in August 1970 in *CRC Critical Reviews in Radiological Sciences*.

Still keeping in touch with the endeavors of their former professor, the Centre Daily Times in State College published an article with a photograph of Pauline taken during her Penn State years (Kurilla, 1971). It was noted that Pauline's career at Penn State was highlighted by beacons of success that continued to provide light to young people studying and working in the chemistry field. Dr. Mary Willard, Pauline's friend and colleague at Penn State and now professor emerita of chemistry, was interviewed for the article. Mary discussed Pauline's avocation for helping young career-minded women

obtain an education and pointed out that her friend had helped many girls get through college at Penn State. Pauline was noted as having her own women's liberation program for energetic and intelligent young women with promise. Mary remembered her friend as an endless worker with relatively good health, an excellent mind, and real understanding and true belief that women should be able to excel in careers as men did. The University knew Pauline as a "very, very vigorous and very fine woman," according to Mary.

Pauline was contacted by telephone to provide information for Kurilla's *Centre Daily Times*' article (1971). During the interview, Pauline spoke of her enjoyment of everything she had done, but the work at TWU and with NASA was "very rewarding." Pauline pointed out that TWU was a career university for women. As for the Snoopy award, Pauline initially thought that it was a joke. She figured Jim Lovell was kidding her about snooping into how their bones were put together because of the number of times she had X-rayed him. Pauline also told Kurilla about her current work in preparing a protocol for a very elaborate 1971 bed rest study. Kurilla thought all of this was pretty exciting work for a woman who was 77 years old. I wonder what she would have thought if she had realized that Pauline was actually 79.

Another of Pauline's honors in 1971 was covered by the *Centre Daily Times* in addition to Texas media. Pauline was included in a biographical publication by Ernest Kay of London, *The 2000 Women of Achievement*. She was selected because she had devised the first method and designed the first equipment to quantitatively measure bone density from X-rays. Over 20,000 children and adults had participated in research that employed this methodology to measure their skeletal status. Another factor was her contribution to the field through the authorship of scientific books and publication of

more than 200 research articles in scientific journals. A photograph included with the *Daily Lass-O* article showed Pauline wearing her infamous fur coat.

Cotton as a food source came under scrutiny in 1971 after geneticists at Texas A & M University helped to develop a glandless cotton seed. The gland was problematic, because it produced gossypol, a pigment that caused adverse metabolic effects when ingested by humans. Protein from glandless cottonseed is safe for consumption by farm animals and humans. Pauline was the head of a nine-member research team studying cotton as a source of protein in the hope that vegetable sources like cotton could help alleviate the increasing cost of animal protein deriving from meat, milk, and eggs. The team included Betty Alford, Bill Stover, and Fred Vogt. TWU was in the rare position of conducting studies on an agricultural product, cotton, for its use as food and also its use in clothing. Laundering was still on the docket during this time as well. Charles Cawley and Pauline published the results of a study comparing sling and loose laundered linen in September 1971. They found that the use of slings to increase production did not have an adverse effect on the work quality. Whiteness retention was nearly the same for both methods and the difference in soil removal and tensile strength loss was minimal, with slightly better scores for linens laundered in the sling.

Christmas 1971. Pauline's Christmas letter in 1971 featured her dogs, Webster Farrar Mack and William Farrar Mack. In it she described a birthday party that she and Mary Sue Farrar had held for the dogs. Staff members, including graduate students from Pakistan, India, and Taiwan, received handwritten invitations to the October event held late one afternoon in Pauline's office. The graduate students' vigorous laughter upon receipt of the invitations was the result of having never heard of a

dignified party being thrown for two poodle dogs. In spite of the laughter, the staff and students came to the celebration and enjoyed cake and coke with the dogs, which were decked out with ribbons, matching nail polish, and new collars. Pauline wrote that she had thought about not sending a letter this Christmas because of other heavy duties, but the influx of cards and notes that mentioned interest in her 1971 letter changed her mind. She wanted her recipients to know that she was still hard at work and enjoying everything. Pauline was planning to teach a course in Textiles in the coming semester, was involved in helping graduate students with their theses and dissertations, and was helping to get out the numerous research projects that were badly in need of publication.

Figure 16. Webster Farrar Mack. Photo courtesy of The Women's Collection, TWU.

Pauline fights perils. Two decades after she came to Texas, Pauline was in her 53rd year as a faculty member and researcher. Kay Crosby, writing for the *Dallas Morning News*, highlighted Pauline's career in "Pauline fights perils with research" (1972). Pauline was currently supervising a staff of some 35 full-time employees and graduate students. Acknowledging the inevitable effects of age, Crosby stated that while Dr. Mack's shoulders were slightly stooped by the years, she was still an intellectual giant. When questioned about her extensive body of work, Pauline attributed it to the fact that she worked like a dog, usually seven days a week. Over the weekend she would try to write a research paper. In discussing her research, Pauline took up the topic of athletes'

eating habits and what they should be eating to maximize their energy levels. According to Pauline, high school boys in particular were likely to work too hard without eating properly. The boys were consuming enormous amounts of snacks that weren't good for them. Our current obesity epidemic speaks loudly to Pauline's lifelong nutrition concerns. Pauline also shared a story with Crosby about the time a prominent Dallas industrialist questioned her on why someone with her background would come to a "little girl's finishing school like TWU." Pauline straightened him out in no uncertain terms: "I told him shortly that this isn't any little finishing school. It's a university for women who want training for careers." During her two decades at TWU, Pauline's endeavors were highly successful in the efforts to recast the University as a premier research institution.

Changing of the guard. One can discern a shift at TWU in 1973. A May article in the *Dallas Morning News* presented current research involving orphans eating food containing cottonseed protein. The study was taking place under the direction of Dr. Betty Alford. Walter Moore had interviewed Dr. Alford for his extensive article and noted the high hopes of everyone involved, from the producers through researchers like Dr. Alford. Moore highlighted the beliefs in the research's great potential held by his longtime friend, TWU President and chairman of the statewide Natural Fibers and Food Protein Committee, John Guinn, and Carl Cox, the committee's executive director. The sole mention of Pauline in this article was in relation to Guinn and Cox, who "both praise Dr. Pauline Beery Mack, one of the nation's outstanding women in research, for her key role in TWU research with protein and fibers" (Moore, 1973). Perhaps another sign was reflected in an issue of the *Journal of Gerontology*. George Vose and Arnold Engel published an article in 1973 in this publication pertaining to the relationship of

radiographic cortical thickness versus age in bones of the hand. While Pauline was cited in the references, she was not a co-author of this research. George was also the sole author of a May 1974 journal article that reviewed the roentgenographic bone demineralization studies of the Gemini Space Flights. Once again, Pauline was cited in the references. Pauline's life work was recognized in 1973 with an invitation to submit biographical material for inclusion in the upcoming issue of *Who's Who in the World*.

Dr. Pauline Beery Mack's Life Story Concludes

In May 1971 Pauline donated 9.805 acres of her East McKinney Street property to the city of Denton for use as public parks. She and Mary Sue Farrar, her former graduate student and live-in companion, moved to a single-story home at 1914 Stonegate in Denton. Pauline's health was being compromised by diabetes. Pauline treated Mary Sue like a daughter, and Mary Sue nursed her. Betty Alford, who had worked for Pauline for a decade, saw a change in Pauline's behavior as she dealt with declining health in her early 80s. Tenacious to the end, Pauline did not want to relinquish her work. However, her abilities to judge potential hires and handle budgetary items were affected. Dr. Mack recommended the hiring of an individual who showed up at TWU with degrees from German universities. The man stole furniture from one of the buildings and had also done so in Dallas. Dr. Guinn reviewed the man's credentials and found they were counterfeit. Dr. Mack was really hurt. It was a sad event for her when LaRue showed up to fire the man.

Figure 17. Mack Park, Denton, Texas. Photo by author, August 2008.

Betty Alford and the current dean met with Dr. Guinn to discuss the issues. Dr. Guinn had brought Pauline to TWU to build the research program and was faced with a difficult situation. However, his response showed his loyalty to and appreciation of Dr. Mack: “I brought her here, she did what I wanted done, she built the research department, and now she’s ill and needs assistance and I won’t abandon her now” (Pyle, 1993, March 9). Dr. Guinn established a plan that would allow them to get the work done, moving Pauline to the side without moving her out. This was one occasion where Betty saw caring on the part of Dr. Guinn, an emotion typically reserved for his children, but very evident for “this woman.” Pauline struggled with her changing role, finding it difficult to give up control. According to Bill Stover, when Pauline was ill her staff members just fell in and did what they knew they should do. They wrote the reports and got them out. He remembered Pauline coming to work during the last year, pretty much out of it. She would stay for two or three hours and then go home. The last time he saw her, she was semi-ambulatory and in a wheelchair. They missed her for a long time after she was gone.

During the latter part of her life, Pauline was hospitalized on a number of occasions. Elizabeth Snapp was serving as captain of one of the Alter Guild teams at St. David’s Episcopal Church. She was charged with dividing up the flowers after

services for delivery to the hospital and to shut-ins. She would visit Pauline to deliver flowers, introducing herself at each visit. Pauline would smile in recognition. Though she was not very talkative, she thanked Elizabeth for coming. While some of Pauline's files and work were lost after her death, Elizabeth was able to arrange for many of her X-rays and papers to become part of the library archive collection.

During this timeframe, George Vose had a grant from the National Institutes of Health to study the bone quality of patients who had fractured a hip. Presumably, the opposite intact hip had the same quality as the fractured one, so hospital staff would X-ray the opposite hip and send the X-ray to George's lab for analysis. Shortly before Dr. Mack's final days, George was surprised to discover that Dr. Mack's X-ray had been sent to his lab for analysis. She had fractured her hip. Dr. Mack was obviously osteoporotic, ironically suggestive of an inadequate calcium diet. Given her trauma, George doubted that she realized that her hip bone was being studied by the very same principle she had developed.

Pauline experienced the onset of renal insufficiency caused by obstructive nopathy in the latter part of September 1974. Four weeks later, Pauline's system came to a halt. Two months before her 83rd birthday, at 8:00 a.m. on October 22, 1974, Pauline died in Westgate Hospital. Diabetes and arteriosclerotic heart disease were contributory factors to her death. Gertrude Adams Lathrop was in Chicago that day, giving her last speech. Several months later she would learn that it coincided with the date of Pauline's death. In retrospect, Gertrude thought that Pauline's Texas years were not her happiest ones because she had lost her husband.

Pauline's funeral arrangements were handled by Schmitz-Floyd-Hamlett Funeral Home. Funeral services were held at 10:00 a.m. on Thursday, two days after her death, at St. David's Episcopal Church in Denton. Dr. Mack, serious about her religion, had talked to Jessie Ashby about a prayer book. She had also been generous in her donations to the church. Jessie was there for Dr. Mack's services. Father Edward C. Rutland, addressing a full church, told the attendees that Dr. Mack had kept this aura about being tough and unapproachable, a mystique, on purpose because it helped in influencing others.

St. David's is smaller than the church Pauline attended in State College. While attending a Sunday service there, I engaged in random thoughts of Pauline's life. St. David's is a place that could bring much solace to an individual. The beautiful interior is dark, peaceful, and earthy, with a cathedral ceiling of dark knotty pine. Old fashioned hanging lantern-style lights and stained glass windows add to the aura. The church is long and narrow, with only two rows of pews and one center aisle. The walls are unusual, made of reddish-brown brick. A circular stained glass window depicting Jesus presides over the alter. It is not hard to imagine that memories of Warren and her parents accompanied Pauline during her times of worship here. Though Pauline attended services at St. David's, Elizabeth Snapp recalled that Pauline did not get too connected at church and was not a member of the choir.

After Father Edward C. Rutland officiated at the service, Pauline would make her final trip back to State College to fulfill her desire to be reunited with Warren. Her last will and testament, bearing her now fragile signature, was dated less than six months before her death- May 1, 1974. In it, Pauline declared, "It is my wish that I be buried at State College, Pennsylvania next to my late beloved husband, Warren Mack."

Having started my quest for Pauline's life story at the site of her final resting place, I found the answer to how she returned to State College in Texas. Pauline at one time had spoken of not having anyone to see her buried in Pennsylvania. Joe Alford, Betty's husband, flippantly replied, "Don't worry, Dr. Mack. I'll see that you're buried." The topic never came up again, but what was probably a decade later, Joe received a call from the funeral director, Dean Mulkey. He called to ask if Joe was ready to go to Pennsylvania, as Dr. Mack had left a note in her file that he would do this. Dr. Mack's attorney, Joe Skiles, was in Hawaii, so Joe Alford signed the papers. Attorney Skiles gave the go-ahead by telephone, so Dean and Joe accompanied Pauline's body to Pittsburgh. When they landed at 9:00 p.m., they were met by a funeral coach company. Early the next morning they drove to State College.

Very few people attended the services that were held at 1:00 p.m. on Friday, October 25, 1974 in Centre County Memorial Park. Pauline had no known survivors. Joe Alford placed the number at about 7 attendees, people he thought were there from Penn State. A woman that Joe could not identify showed up with her driver. Dean offered to open the casket so she could pay her last respects, but she declined. After seeing Pauline's copper casket, which was top of the line, the woman said, "Pauline always went first class." The rain was coming straight down. Dean looked at Joe and said it was one o'clock and no one else was coming. Following Dean's remark to Joe, "Let's get started," the rain ceased and the sun came out. The same woman responded, "Pauline's in charge of the weather, too." It is highly probably that the woman was Pauline's friend, Mary Willard. Mary mentioned in a 1991 interview (Folkenroth) that she had attended Pauline's funeral. She pointed out that all of Pauline's family and friends had passed

away by the time Pauline died. Mary talked about the terrible storm that took place that day, recalling only that she, the undertaker, and the minister were present. Joe Alford's description of the woman as short, stocky, and another Dr. Mack, fit Mary as well. Reminiscing in Folkenroth's article about her friend, Mary spoke of Pauline's love for teaching and her subject. Combined with her energy and charm, these attributes had made her a dynamic presence in the classroom. Mary Willard, Pauline's friend and colleague, pioneering scientist and criminalist, was there when Pauline first came to State College and was there for her final return. Mary outlived her friend by a number of years, dying in 1993 at approximately 95 years of age.

Pauline's casket spray, like the one she had chosen for Warren, was made of red roses. Joe made arrangements for a grave marker and remained until Pauline's grave was closed and grass was put on it. He brought the memorial book back to Texas. Nearly two dozen years after persuading Pauline to become a Texas woman, Dr. Guinn now held her memorial book in his hands.

Media Memorials

Following Pauline's death, an array of articles appeared that summarized her many accomplishments. Her personal achievements and professional honors formed a formidable list. Dr. Pauline Beery Mack was described as one of those people who had to know. She pursued knowledge not just as a goal, but as a passion. Her work habits and extensive knowledge earned the admiration of colleagues and national prominence. TWU President John Guinn lauded Pauline as one of the all-time greats in her field. He acknowledged her unique contributions in the development of research programs and her leadership for the advancement of knowledge in her research fields. Dr. Guinn held

Pauline in the highest esteem and noted that her decades-long international reputation was well-deserved. Pauline, sometimes blocked from seeing Dr. Guinn at the office by his over-protective secretary, would head to Dr. Guinn's house and wait until he came home. She would be waiting for him no longer. Dr. Mack's death, as one reporter noted, created a void which likely would not be filled. One of a kind, Dr. Pauline Beery Mack was one of the individuals who made Denton dynamic.

Bequests

Pauline, whose immediate family had predeceased her long ago, left her residence at 1914 Stonegate, along with all the furniture, appliances, and other personal property within, to her live-in companion, Mary Sue Farrar. Mary Sue was already the beneficiary of Pauline's teacher retirement. About a year before she died, beneficiaries needed to be updated. LaRue took the papers to Pauline. She sat there for a while. LaRue then asked her if she wanted to name Mary Sue and Pauline replied in the affirmative. In her will, Pauline also directed that $25,000.00 be placed in trust to further her research work at TWU in the field of bone density and other related studies. The trust was to be used for an annual Pauline Beery Mack Fellowship given to a student or faculty member of TWU. The remainder of her estate was bequeathed to Mary Sue. Inheritance tax on the estate was nearly as large as the trust, at $23,701.58.

Epilogue

Longitudinal Nutrition Studies Continue

In 1978, Jessie Ashby was involved in the start of a 20-year follow-up study with participants from Pauline's bone density research conducted in the 1950s. Ginger Brewer, the principal investigator, Alice Milner, and Betty Alford were also involved with the

project. Bill Stover served as technician on both the original and the 20-year follow-up studies. A lengthy article provided pictures and clues in TWU's attempt to locate the original participants:

> Consistent clues for those persons who think they might have been involved: You would have kept a 7-day diet record for at least one week; you would have been X-rayed and would have had blood drawn for tests; you would have taken the endurance (fatigue) test, and the dark adaptation test in which you sit in the dark for twenty minutes trying to see spots before your eyes. (Where are, 1978).

During the original testing, approximately 4,000 individuals were evaluated on multiple health parameters. In the 20-year follow-up, 352 of the original participants were re-evaluated on the same parameters. In addition to hand and foot studies, the researchers were able to add forearm studies. They now had a nearly-portable Norland device with this capability.

Dr. Nancy DiMarco, who came to TWU as Assistant Professor in the Nutrition and Food Sciences Department under Dean Betty Alford, became aware of Pauline from the moment she set foot on campus. The 20-year follow-up study was already underway. The basement in Old Main was lined with wall-to-wall filing cabinets containing an unbelievable amount of data from the original studies. Bill Stover, with the mind of a steel trap, had been absolutely meticulous. The log book listed all 4000 participants of the Texas studies, providing numbers that were used in the follow-up studies.

In 2006 Dr. DiMarco became the new Director of the Institute for Women's Health (IWH) at TWU. She sought to locate participants who had been involved in both the original studies and the 20-year follow-up. The intent of the 50-year follow-up was to

analyze the anthropometric and lifestyle variables on bone mineral density over time. Dr. DiMarco, the principal investigator for the 50-year follow-up study, was looking to the study to determine the longitudinal changes in pharyngeal bone density and the usefulness of pharyngeal bone density in predicting fractures. The investigators found a strong correlation between hand X-rays and lumbar spine X-rays, suggesting that hand X-rays can provide a good picture of overall bone density health. Data from a subset of the participants were used to investigate the relationship between dietary intake and bone mineral density in postmenopausal women.

The 20-year follow-up data and the baseline original X-rays were sent to Compumed about 10 years ago for scanning and digitizing. When the company compared the digitized bone density scans to Bill Stover's work with the wedge, they found a remarkable singularity. Dr. DiMarco has now overseen five studies drawing from the pristine data made available by the efforts of Pauline and her colleagues. She continues to seek grant funds to expand the studies, as it is costly to transport individuals back to campus. She and her colleagues are anxious to purchase a real X-ray machine for hand X-rays. The quantity of data collected by Pauline and her colleagues is a significant contribution. Human studies typically did not have that level of longitudinal data relevant to the aging process. The massive files at TWU from the nutritional studies initiated under Pauline's direction contain a wealth of data still waiting for the opportunity to be entered into modern computers for processing. Who knows what valuable scientific insights remain within those cabinet drawers?

Dr. DiMarco graciously spent some time with me in her conference room, sharing her research and knowledge of Dr. Mack. Her enthusiasm and energy brought Pauline's

work to life, as did our visit to that impressive line-up of filing cabinets. Pauline was literally in the conference room with us, through the documents from her office and her portrait that Dr. DiMarco had retrieved from storage to adorn her conference room wall. As we readied to part, Dr. DiMarco offered her sentiments: "Pauline was an inspiration to me. She needs to inspire another generation of women to pursue science with excellence."

NASA Nostalgia

TWU's participation in NASA studies was highlighted again in 1994 on the occasion of the 25th anniversary of Neil Armstrong's moon walk. Dr. Betty Alford and Dr. Bill Stover were interviewed for an article that ran in the *Denton Record-Chronicle* (Becka). They discussed the excitement, enthusiasm, and pride involved with participation in TWU's NASA studies. Dr. Mack's reputation was instrumental in TWU's selection for the studies. Betty and Bill declared that Dr. Mack was a real go-getter, who frequently called her researchers into the lab in the wee morning hours. Their research generated a sense of urgency. Bill wondered how they ever became involved. To him, going to the moon and back was like a fairy tale. It was a hectic time with lots of pressure. Bill also spoke of Dr. Mack's chagrin at not being allowed on the aircraft carrier, with the result that she couldn't oversee her own project. Dr. Mack was determined to go aboard anyway until they said they would cancel the contract. Despite this, during the space launches, Dr. Mack was transfixed, loving everything about it. Pauline's research projects put TWU on the map. One has to wonder what unknown territories she would map today given the advances in science, technology, engineering, and mathematics.

Parting Ways

Carl Cox knew Pauline well through his work for the Texas Cotton Research Committee and their numerous funding trips to Austin and Washington, D. C. The Pauline he knew succeeded because of equal parts brains, style, and chutzpah. She wasn't afraid of anything. Pauline's way of talking to men, according to Carl, overwhelmed them. He wouldn't call it flirting; she just knew how to do it. In summing up her immense accomplishments, he noted that Pauline was one of the first researchers to discern that most hip fractures in the elderly were not the result of falls- the hip would break and cause the fall. Pauline was one of the first to accurately demonstrate how calcium reacts in the bone cavity.

The last words George Vose remembers Pauline saying to him occurred at Pauline's final house party, "George Vose, my oldest friend." Pauline cared greatly for her friend and colleague. The man she had known since he was 18 years of age, who had chauffeured her, researched with her, served as confidant, and who had defended her research to NASA, said his good-byes. It is not an easy thing to say good-bye to Pauline. George's friend and Pauline's former employee, Jim Cain, expressed his feelings to me when we were discussing Dr. Pauline Gracia Beery Mack: "I hope you treat her well." I hope I have.

CHAPTER V

INTERPRETIVE ANALYSIS OF DATA

Introduction

In Chapter IV, Dr. Pauline Beery Mack's life story was presented chronologically from the author's interpretive view. Her life story was constructed from archival and other documents, threaded with stories from interviews conducted by the author and others. Recognizing that the author's particular biases and values cannot be totally isolated from the text, from the interpretive approach the author's presence and point of view are visible in the unfolding narrative. Chapter V commences with the requisite data analyses that serve as the basis for responding to the research questions guiding this study. The analyses of data segue to answering five of the study's six research questions. In addressing these questions, Dr. Mack's life story is re-examined and analyzed within the contexts of the theoretical frameworks presented in Chapter II of this study: the psychobiosocial model, constructivism, creativity, perspective of the field, and the capstone framework of leadership. Appendices C through H of this study include specific aspects of the analyses of data and will be expounded upon as relevant in this chapter. In addition to summarizing the study, Chapter VI then conveys the study's conclusions and implications for secondary and tertiary educational leadership. Chapter VI, in addressing the instrumental aspects of this case study, answers the study's sixth and final research question.

Data Analyses

Data Sources

The data for this study derived from three main sources, supporting the triangulation process. Substantial document materials were obtained from Pennsylvania State University Archives, The Women's Collection at Texas Woman's University, original publications, news media archives, and other applicable sources (see Biographical Bibliography for complete listing). The Special Collection at Texas Woman's University provided interviews that had been conducted with six individuals who knew Dr. Mack in varied contexts during her two plus decades in Texas. The author, cognizant of the potential limitations on available interviewees due to the era in which Dr. Mack lived, followed Simon's (2008) recommendations about pilot subjects if they are to be included in the total study sample. The author was able to conduct interviews with nine individuals during the pilot and full study. Two of these individuals knew Dr. Mack in both contexts- PSU and TWU. The remaining seven were involved in the Texas context only. Two of the individuals interviewed by the author were also interviewed at TWU in 1993. This provided a unique opportunity for the author to examine the consistency of information provided to different interviewers with an approximately 15-year interim period.

Having multiple data points with varied analyses is particularly important given the diverse perspectives that arise in different contexts combined with the passage of time and potential weakening or corrosion of memories. The author utilized member checking throughout the study, verifying information with interviewees and seeking additional

information and corroboration as new information surfaced from documents and other interviewees.

Coding

The preponderance of document data for this study, combined with interview data, provided a challenging task in terms of sheer quantity and multiplicity of potential strategies. In order to effectively and accurately respond to the research questions, I turned to multiple iterations of coding data from each of three sources- documents, interviews conducted by the author, and interviews conducted by others. The first coding was accomplished using very broad categories relating to attributes, teaching methodology, influence, barriers, advocacy/support, and relationships. In a second iteration, data were clustered according to emerging patterns. Data were not mutually exclusive, thus some data appear in more than one area. Appendices C, D, and E delineate the second iteration of the data coding by each source. Several attribute categories were revealed across all three sources: confidence, control, change agency, intellect, nonconformance, humor, generosity, persuasiveness, networking, communication, expectations, creativity, persistence, vision, stringency, productivity, and ambition. The findings in these areas will be discussed within the answers to the research questions.

Pattern Matching

Once attribute patterns were revealed in the data, two variations on pattern matching were conducted. The first involved a comparison of the relative degree of evidence provided by each of the three data source types (Author Interviews, Interviews by Others, and Document Data) as contributory factors in identifying the patterns. The

following scale was used for this evaluation: (a) little evidence attributable to the data source; (b) moderate evidence attributable to the data source; and (c) substantial evidence attributable to the data source. The ladder diagram comparisons are found in Appendix G. Table 1 presents a summary of these comparisons and reveals some variations which will be discussed in the responses to the research questions.

Table 1

Comparison of Attribute Evidence Contributed by Source

Attributes	Relative Degree of Evidence from Sources
Confidence, Creativity	Substantial- Author Interviews, Document Data Moderate- Interviews by Others
Control, Stringency	Substantial- Author Interviews, Interviews by Others Little Evidence- Document Data
Change Agency, Intellect, Generosity, Persuasiveness, Networking, Communication, Persistence	Substantial- Author Interviews, Interviews by Others, Document Data
Nonconformance, Humor, Expectations	Substantial- Author Interviews, Interviews by Others Moderate- Document Data
Productivity	Substantial- Document Data Moderate- Author Interviews, Interviews by Others
Vision, Ambition	Substantial- Interviews by Others, Document Data Moderate- Author Interviews

The second variation on pattern matching involved comparison of the relative degree of evidence for attributes as revealed in the two major contexts of Dr. Mack's life story, the PSU years and the TWU years. The same scale was used for this evaluation: (a) little evidence attributable to the data context; (b) moderate evidence attributable to the data context; and (c) substantial evidence attributable to the data context. Attribute

comparisons by context are included in Appendix H and variations between the two contexts are presented in Table 2. The variations are discussed within the research question responses found later in this chapter.

Table 2

Contextual Attribute Variations

Attributes	Relative Degree of Evidence from Contexts
Confidence, Change Agency, Intellect, Humor, Persuasiveness, Networking, Communication, Creativity, Persistence, Vision, Productivity, Ambition	Substantial- PSU and TWU
Control, Stringency	Little Evidence- PSU Substantial- TWU
Nonconformance, Generosity, Expectations	Moderate- PSU Substantial- TWU

Additional Data Analysis Strategies

Concept mapping. In what could be considered a third iteration of data coding, I constructed an attribute concept map utilizing the attributes that were revealed in the first two iterations. Utilization of concept mapping as a visual diagramming tool facilitated the emergence of attribute relationships that would be less evident in linear or matrix strategic approaches. Concept mapping aligns well with the constructivist-interpretive paradigm of this study and the constructivist framework examined in Chapter II of this study. Figure 18 depicts these relationships, which will be addressed in subsequent responses to the research questions. The attributes and their relationships as presented in this concept map are intrinsic to the discussions of Dr. Mack's interactions with others and her handling of situations presented by the external world: (a) educational and career

decision making; (b) transforming junctures; (c) teaching methodologies; (d) influence; (e) barriers; (f) advocacy and support; and the overarching area of (g) relationships.

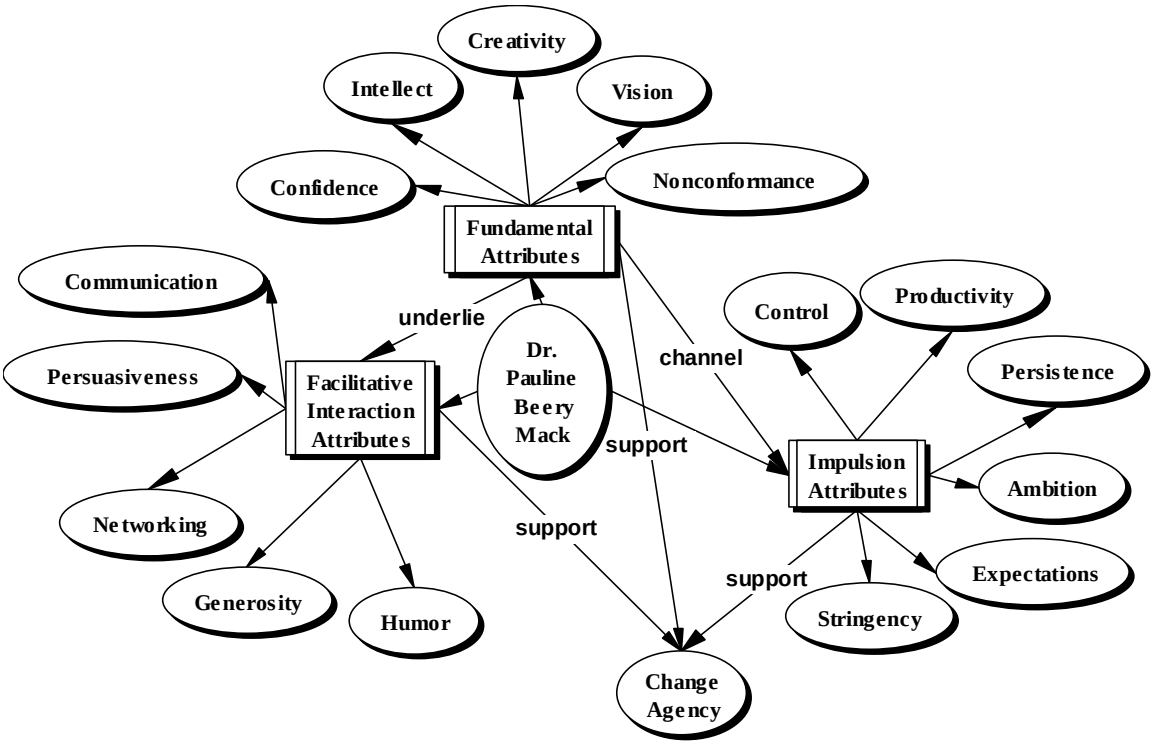


Figure 18. Dr. Pauline Beery Mack Attribute Concept Map.

Timeline. Another visual tool utilized in the analyses of data for this study involved the creation of a timeline, or chronology of events. This endeavor is very beneficial in translating the concepts of history and time from the abstract to the concrete. When sequencing events, it is easier to perceive the amount of time between events. Timelines offer the added advantage of revealing patterns and relationships related to time and place. The chronology of events in Dr. Mack's life appears in Appendix F of this study.

Contextual understanding. In agreement with Pinsker (2003) on the value in knowing the setting in order to know the person, I sought to build my understanding of

Dr. Mack's life story by developing personal knowledge of key relevant settings. In State College, I spent time on the Penn State campus, including visits to Pond Laboratories. I ate at one of Pauline's favorite places, the Nittany Lion Inn. I visited the site of the Old Main Art and Gift Shop and her former home on East Hamilton Avenue. In addition, I visited the original State College High School located on Fairmont Avenue, one of the sites for the Mack's 25th wedding celebration. Pauline attended St. Andrews Episcopal Church in State College and St. David's Episcopal Church in Denton, so I attended services at each location as well. I walked the campus at TWU and visited Dr. Mack's former offices. I saw the rows of filing cabinets storing her data. Spending time in her first Texas home on East McKinney Avenue in Denton illuminated my understanding of her life in Texas. From Mack Fields to the Chamber of Commerce to her second home in Texas, I attempted to not leave any stone unturned in knowing her settings. The extensive photographs I took have helped in documenting this journey.

Fortified with the data analyses, visual analytical tools, and knowledge of the settings, it is time to return to the research questions that guided this study. Connections to the study's theoretical frameworks are examined where applicable.

Contributing Factors to Career Engagement and Perseverance

In order to address engaging, educating, and retaining individuals in STEM fields, the first research question guiding this study focused on what factors contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science. Some identifiable factors have strongly emerged from this study, while others are partially supported and can be surmised. After separate consideration of discernable factors, Halpern's psychobiosocial model (2006), which

takes into account the mutual influence of psychological, biological, and social variables, provides a framework for considering the interrelatedness of those factors.

Maternal Influence

Educational expectations. The little that is known about Dr. Mack's childhood, adolescence, and college years speaks to strong maternal demand for excellence in school work. Only the highest grades were acceptable to her mother, and Pauline fulfilled those expectations by being at the head of her class throughout her public schooling. She continued to adhere to those expectations in high school, pursuing a demanding course of study with four years each of Latin, German, and mathematics. Pauline's mother was so stringent in her expectations that she was prepared to pull Pauline from university studies when she received a medium grade on her first Latin quiz. It is at this point that Pauline's fundamental attribute of intellect and facilitative interaction attribute of persuasiveness contributed to her successful pursuit of an education in the sciences. Having earned an excellent grade in chemistry, indicative of her propensity in this area, she and her chemistry department head persuaded her mother to give her another opportunity. With a major in chemistry, and minors in physiology, mathematics, and English, Pauline established the educational foundation for teaching and research in a scientific field. She also fulfilled her mother's expectations, improving her grade in Latin. Subsequently, Pauline pursed a master's degree at Columbia University with great interest and enthusiasm in her areas of study- her work with Dr. Kendall in physical chemistry (her major) and her work with Dr. Sherman in physiological chemistry and nutrition (her minors).

Work ethic. Dr. Mack's work ethic was developed at a very young age. Her mother was a strict disciplinarian who expected Pauline to put work before play. Pauline had responsibilities in the family store when she was little more than two years old. While she was maintaining a rigorous course of study at Missouri State University, Pauline was simultaneously working as a student assistant in the physiology laboratory. Her work in preparing materials and specimens for study was another step toward the role of research scientist.

Role models. Pauline was raised in her family's general store. While growing up, she observed her mother maintaining her own separate women's tailoring business, which she continued when she accompanied Pauline to college. In maintaining separate work interests, modeling a strong work ethic in addition to expecting one from her daughter, Pauline's mother appears to have been very independent in her marital relationship. This independence is also evidenced by her spending the better part of three years living with Pauline at college and her eventual closing of the family store with Pauline's help while her husband, Pauline's father, traveled abroad.

Opportunity

Pauline was raised in comfortable financial circumstances. Music lessons were part of her childhood, and she continued these studies during her college and high school teaching years. Her familial economic status enabled pursuit of tertiary studies, though as previously discussed, she was expected to work hard and perform at the highest levels.

Time and place also provided opportunities and limitations on Pauline's decisions regarding teaching and scientific research. After graduating from Missouri State University, Pauline taught science for two years at the high school she had attended.

Reflective of her impulsion attribute, ambition, Pauline advanced her career at another high school, becoming science department head. Inequitable treatment by her high school principal prompted the decision to move on. The timing coincided with plentiful job options due to young men entering the military (World War I) and the limited supply of women science teachers. This third high school position, also as science department head, was only for one year, as Dr. Pond from Penn State recruited her from her Columbia studies. The impact of World War I on the supply of men as students and teachers created opportunities at the tertiary level as well. Dr. Pond was striving to align Penn State's Chemistry Department with changes in the field and wanted to include manufacturing, industrial, and textile chemistry in his department. Pauline was academically prepared to take on the challenge of developing a chemistry program for women. Having always lived up to maternal expectations and experiencing continuing successes, one can surmise that her fundamental attribute of confidence played a role in her acceptance of this combined teaching and scientific research position.

Pauline's options in the decision-making process were also constrained by time and place. After graduating from Columbia, her desire was to pursue pure chemical research. She found that it was still a man's field and gradually developed her niche in the application of chemistry to medical, household, and industrial problems. Pauline had spent considerable time and money in preparation for a professional career, enjoyed her professional work, and was driven by her ambition.

Support

In addition to familial support, Pauline found support elsewhere. The head of the chemistry department at Missouri State University, Dr. Hermann Schlundt, was

instrumental in Pauline's switch to chemistry. Pauline excelled in chemistry and developed a rapport with him. His interest in her studies and intervention with her mother earned Pauline's admiration and they became mutual lifelong fans. Pauline also considered Dr. Pond to be her friend, as well as leader. She valued his support in her career change, cut short by his untimely death in her first year at Penn State. When Pauline ran into interference with her doctoral research at Penn State, she garnered support from individuals in other departments, her husband, and her mother. Her networking ability and persistence are evident in these interactions.

No evidence surfaced during this study to suggest that Pauline ever considered not persevering in her field after she switched majors at Missouri State. The combination of her fundamental and impulsion attributes, enhanced by her facilitative interaction attributes, provided Pauline with the requisite mental equipment, constitution, and unfailing interest to stay the course. Her parents and husband provided substantial support of Pauline's career while they were living. Pauline created an alternative support structure following their deaths.

Psychobiosocial Model as an Interpretive Framework

Halpern's (2006) psychobiosocial model, presented in Chapter II of this study, provides a productive lens for interpreting Dr. Mack's educational and career decisions. Figure 19 depicts this model and interpretive lens. The psychobiosocial model rejects a nature-nurture continuum in cognitive outcomes in favor of one that recognizes the mutual influence of psychological, biological, and social variables. Dr. Mack's precociousness and intellect are indicative of a biological predisposition for learning particular concepts. Her learning experiences in primary, secondary, and tertiary settings

contributed to further changes in areas of the brain. Psychological variables came into play, as success was demanded and resulted in her own expectancy of favorable outcomes. Her psychological variables of enthusiasm for and interest in scientific disciplines affected how readily she learned, which was also affected by her prior learning experiences and biological predisposition.

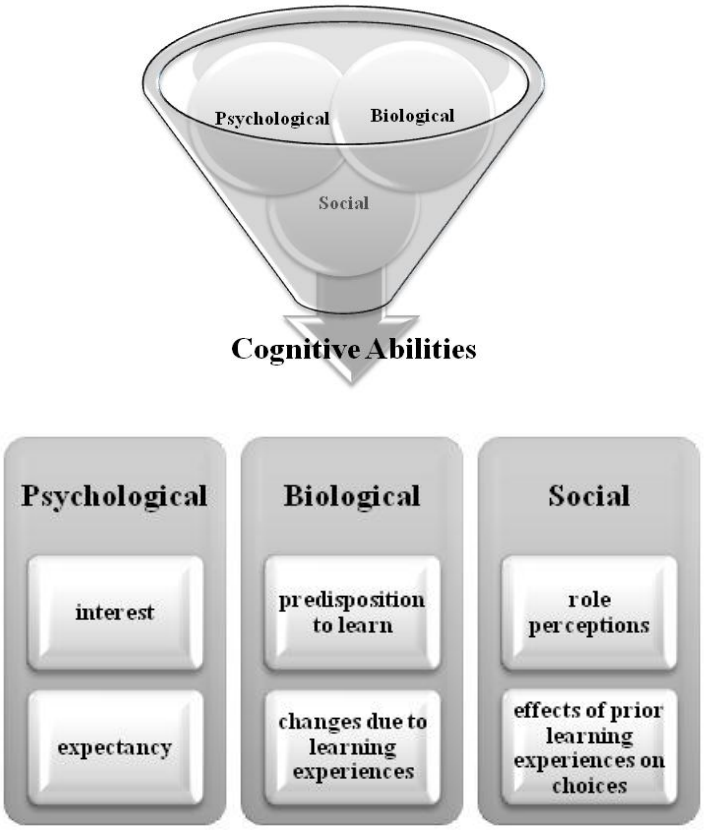


Figure 19. Psychobiosocial Framework for Interpreting Dr. Mack's Decisions.

Social variables exerted their influence in terms of Dr. Mack's perceptions of the female role. She grew up in a matriarchal household, with an independent and demanding role model who expected and modeled a strong work ethic. Her maternal role model also expected, valued, and supported excellence in academic performance. An only child in a demanding and supportive household, Pauline was socialized to demand and expect much

of herself. Pauline's socialization, mutually influenced by biological and psychological factors, provided her with a somewhat gender-neutral perspective and attributes more typically considered masculine.

When examining Pauline's educational and occupational choices, the mutual influences depicted in the psychobiosocial model situated Dr. Mack to value her educational and career options and to perceive that she would have a high degree of success within the options that were available to her in her era. Those influences would also lead her to expect continued support from her parents, her future husband, and others.

Relationship of Traits and Behaviors to Theoretical Frameworks

In order to more fully understand the complexity of Dr. Mack's life story and its implications for secondary and tertiary STEM leadership, the second guiding question of this research study addressed identifying what, if any, patterns or connections to the theoretical frameworks of constructivism, creativity, and leadership were evidenced by the traits and behaviors displayed by Dr. Mack. Each of these frameworks will be considered in turn, though as the psychobiosocial model suggests, human complexities and mutual influences on cognitive outcomes would indicate interrelatedness.

Constructivism

Constructivism as a paradigm, examined in Chapter II, considers learning to be a recursive, non-linear building process incurred by active learners interacting in both physical and social environments (Fosnot & Perry, 2005). Its nonlinear focus involving construction of knowledge through individual and social processes moves beyond the nature-nurture argument in congruency with the psychobiosocial model. Given that

constructivism is a theory about learning, it makes sense to examine Dr. Mack's traits and behaviors from dual perspectives. The first involves her role as a learner. The second involves her role as a teacher, as her traits and behaviors in this context reveal her perceptions of her students as learners, as well as her perceptions of the nature of knowledge.

Dr. Mack, the learner. Whether or not Dora Woodford, Pauline's mother, was cognizant of Vygotsky's zone of proximal development (ZPD), it is evident that she scaffolded Pauline's learning in the family general store. Pauline was assigned her own special department in the store when she was little more than two years old. One can presume that Pauline attained greater competency and knowledge in this early learning experience with adult support.

At Missouri State, Pauline's success in Latin appears to have been below her typical performance under the direction of a teacher who was characterized as an elderly, acid-tempered spinster. The fractious social process in this context perhaps interfered with her construction of knowledge and/or her ability or desire to convey that knowledge. Pauline was very successful in learning science in the classroom and through her work as a student assistant. In her Columbia University studies, Pauline was an interested and enthusiastic learner.

Evidence from Pauline's lengthy career indicates that she was a lifelong learner who was incredibly knowledgeable. She was characterized as one of those people who had to know. An individual with a probing, productive mind, she continually interacted with her environment. Adapting through assimilation and accommodation, she continued to develop new conceptual structures throughout her life. Pauline would see something,

wonder why, and would devise a methodology to determine the answer. If a new field came up, she managed to get into it, develop it, and turn it into a program on campus. Her work was challenging enough to engage her, compelling enough for her to persist, and satisfying in its yield. Pauline persisted in her learning endeavors. Her persistence, also very evident in other contexts discussed later, could be considered legendary.

Pauline was also a constructor of networks. Much of the knowledge that she attained and contributed to her field and the general public was derived in collaboration with others. The quantity and diversity of people that she engaged in research and other projects- from different organizations and fields, students, colleagues, employees, study participants, and family members- are astounding. These social processes fed her drive to know and grew her store of knowledge. The same social processes assisted her collaborators in constructing their own knowledge.

Pauline, the learner, continually built and reconstructed her knowledge. Given her traits and behaviors, one can logically conclude that she did not view knowledge as waiting to be discovered as a fixed body of facts that exist independently of the knower. With her behavior and traits as a learner, one would expect that as a teacher she would not view students as passive containers waiting to be filled.

Dr. Mack, the teacher. In the context of teaching, Pauline's traits and behaviors can be considered from three perspectives- her work as a classroom teacher, her work in guiding graduate students, and the actual work. Pauline was known as an amusing and spirited teacher. Her lectures were entertaining, and she communicated to her students her enjoyment of the subject and her work with them. She was adept at getting her students' attention, whether it was through demonstrations (and explosions), the use of visuals, or

her sense of humor. Dean Wendt remarked with displeasure that she did anything to interest and amuse her students. Some of her students at PSU noted her classes were so enjoyable and helpful that they were worthy of an admission fee. Pauline tutored students on her own time, refusing compensation. She was patient with students who needed additional learning time and encouraged talented students to expend greater efforts. Her work as a classroom teacher evidences her intellect and creativity. Pauline's nonconformance is reflected in her style of teaching and the response of her dean. Her generosity in giving of her time and efforts and her humor are readily apparent. Her persistence is revealed in her dedication to getting students where they needed to be, whatever it took. One can see why the Class of 1923 voted her as their most inspiring teacher.

Pauline's traits and behaviors in her classroom teaching reflect several connections to a constructivist framework. The basic tenet of constructivism is that of learners actively constructing knowledge in physical and social environments. Pauline comprehended the social nature of learning. Her learning environment made challenging subjects enjoyable and her varied methodologies engaged the students. She did not expect them to be passive in the process. Her work with students in their ZPDs is apparent in her tutoring and accelerating endeavors.

Pauline spent a considerable amount of her time and efforts directing the work of graduate students who were conducting research for theses or dissertations. It was considered a privilege to have the opportunity to study with her. She was very committed to her work with graduate students and had a personal zeal for research. In this context, additional attributes and behaviors emerged. Pauline was very demanding of her graduate

students and had high expectations for the quality of their work. She suggested problems for study and extended the scope of their research ideas. She provided whatever assistance was needed, and spent untold hours laboring over their drafts and working with students. In her Denton home, she provided space for students to leave their work spread out. Pauline expended her own funds on needed equipment to support their research. Cognizant that graduate students needed opportunities for interaction, she held social events for them. Pauline had recognition ceremonies for outstanding students and strove to help them develop awareness of the importance of education and of their importance as people. Her students all had to help each other.

Research inherently involves active construction of knowledge. Active construction of knowledge implies teachers attempting to engage students in working on knowledge, rather than absorbing it. In her work with graduate students, Pauline excelled at improving the quality of work provided to students. She was tenacious in her pursuit of relevant research and funding and also contributed her own funds to purchase equipment that would enable students' research endeavors. Schlechty's Working on the Work framework (WOW) (2002; Sparks, 1998), reflective of the basic tenet of constructivism, provides a lens for looking at Pauline's expectations for graduate work. All ten areas defined in Schlechty's WOW framework, discussed in Chapter II, are evidenced in Pauline's endeavors with her graduate students. The focus was on the product and her standards for work were clear and compelling. She guided students in their work so that initial failures would not become ultimate failures. Her students were aware of the significance of their work. She facilitated their association with each other and their support of each other. Variety and novelty were endemic to their work. Students had

choice in their research topics and approaches, though she would suggest topics and extend the scope of their studies. Students' research was authentic, with many publishing the results of their studies. The work led to outcomes in industry and other organizations. Their work had content and substance. Pauline was so knowledgeable that students learned from just being with her. Organization of knowledge was a strength for Pauline. Given the successes of her students in their research and publications, one can presume that her hours of laboring over their papers with them facilitated their organization of knowledge. Authentic engagement of her students supported their construction of knowledge. Some of her students did have a love-hate relationship with her during the process, given her demanding expectations. Many acknowledged her contributions to their subsequent successes.

Creativity

Person lens. Many constructs of creativity have been put forth, some of which were examined in Chapter II of this study. Creativity perceived through a person lens focuses on the attributes of the individual. General agreement exists on several attributes displayed by creative individuals. These include a high IQ, originality, articulateness, and imagination. Dr. Mack's brilliance was consistently referred to by others over the course of her life, including the accolade at age 81 that she was still an intellectual giant. Not bothered by the perspectives of others, she was unique and noted as one of a kind. She produced original work, including inventing methodologies like the one used to monitor changes in bone, that contributed much to her fields. She formulated programs of study and research. Her Pennsylvania Mass Nutrition Studies charted new territory in type and scale of data collection. Articulate doesn't begin to describe her communication skills.

She was gifted at being in touch with people. A popular speaker, she could tailor her presentation to any audience. She could convince people that they wanted to do something, even when they had absolutely no initial desire or interest to do so. She could charm anyone she chose to charm. Her communication skills were also evident in her prolific writings. Dr. Mack's imagination was revealed in her innovative approaches to research. Her foresight situated her as a pioneer in her fields. Dr. Mack recognized the potential of an entirely different way for human physiology to function. She saw possibilities where none were evident. Able to see what could be, she used her imagination to reach others- whether this was in the classroom, through her innovative *Chemistry Leaflet*, or *Stuff, The Story of Materials in the Service of Man*. Dr. Mack's imagination brought her and her colleagues into the folds of the space era.

Creative people typically form independent judgments. Dr. Mack was highly confident in her work. She was adamant about the health hazards of lead weighting in fabrics in spite of research to the contrary. She was not deterred by others who initially scoffed at bone research. She was not bothered by the perspectives of others and came to her own conclusions. Creative individuals are also associated with the willingness to take risks. Dr. Mack was not afraid of anything and took on many challenges over the course of her life. From accepting Dr. Pond's invitation to build a women's chemistry program at Penn State to taking on President Guinn's desire for a premier research program, she was up for the challenge. Her methodologies were challenged, but she was willing to risk ridicule in the knowledge that she was on a productive path.

Dr. Mack was legendary in the creative attribute of perseverance. In the face of opposition and without Dr. Pond's support, she created her chemistry program at Penn

State. She was tenacious in her pursuit of industry standards to guide consumers. Lack of funds was never a deterrent. Dr. Mack excelled at locating funding sources and convincing others of the benefits to supporting the research she was directing. She also contributed her own funds in order to advance her work and the work of her students. She was successful in hassling the Pennsylvania Department of Health for permission to take her nutritional research files from PSU to TWU. Dr. Mack was driven to get things done and would do battle to get what she wanted. She was not one to rest on her laurels. Blocked from seeing Dr. Guinn at times by his overprotective secretary, one can only imagine, knowing her well, that he wasn't surprised to find her waiting for him at his home.

Creative individuals are also known for their curiosity. Dr. Mack was one of those people who had to know. Even in casual, social circumstances her mind was generating questions to be answered. Sitting at a football game, she was pondering why so many football players had such thick necks. There was another research question. Novelty and challenge appealed to her inquiring mind. She was enthused about new things, learned about them, and put them to practical use. One of her greatest contributions, extensive longitudinal nutritional research, reflected her drive to know all facets of the effects of the quality of nutrition at every stage of life.

A high degree of motivation is another trait associated with creative individuals. Dr. Mack's work was her life. She knew what she wanted and was driven to accomplish her goals. Her professional work was so important to her that she delayed her marriage for four years. She was driven to get the job, whatever it was, through means that she would find if it took scouring the earth. Dr. Mack was zealous as a researcher and highly

motivated to support others in becoming successful in their work as well. One of her students noted that he didn't think there was any case in which she would fail to find enjoyment or to find something worthwhile. She loved the pursuit of knowledge and had the intrinsic motivation to develop hers and others and to communicate the results on an international scale. Dr. Mack's motivation is also seen in the incredibly long hours she worked over the course of almost her entire life, until health intervened in her final year or so. She would work any amount of hours to help students, doing anything for those who were putting in the effort. Dr. Mack mentioned to a reporter that she frequently wrote research papers over the course of a weekend. In some cases, one could consider this to be hyperbole. However, the high volume of her output and the comments by others that she could write for hours give credence to her claim and demonstrate her motivation in communicating to others. Dr. Mack's motivation is also revealed in the prolific networking and presenting that she engaged in over the course of her lifetime.

Conflict is also a hallmark of creative individuals. They are likely to experience conflict involving their personal lives or in interactions with their social environment. Dr. Mack engendered polarized feelings in her relationships with students, employees, colleagues, and others in her field. Her relationships were very complex, balanced on the positive side by her intellect, humor, generosity, and communication skills. Tipping the scale to the negative were her controlling nature, high expectations, stringency, and her change agency.

Dr. Mack expected the highest quality work from her graduate students. She would expect their work to be letter perfect, and would often call upon them at any time of day or night. Her students respected her for her knowledge and ability, but many

absolutely hated her demanding process. Afterward, many revered her and acknowledged her contributions to their later successes. However, some never got past the negative feelings engendered in the process. During interviews, true love was expressed by some, while others revealed bitterness tinged with grudging acknowledgement of her genius and accomplishments. The same pattern of polarized emotions was evident in her relationships with employees and colleagues. Those who loved her would do anything she asked. She was feared by a few, laughed at by some, and envied by others for her marvelous mind and accomplishments. Dr. Mack was not discrete in showing her displeasure, which engendered lingering negative emotions in a few recipients. Her intrusiveness on private lives and her highly demanding work expectations did not sit well with some.

A major factor in Dr. Mack's conflict with colleagues was found in her role as a change agent. At PSU, she developed a chemistry program for women and instituted the study of textile chemistry and built it into a field for graduate work. Consolidation of many industrial grants and projects under her direction at the Ellen H. Richards Institute engendered jealousy among some colleagues. Her departure for Texas, with her research files and a number of staff members, also led to bitterness on the part of a few who remained at PSU. Dr. Mack was also hired by President Guinn to bring about major change at TSCW. In transforming the traditional home economics program to a major research program in a newly created College of Household Arts and Sciences, many feathers were ruffled. She fulfilled Dr. Guinn's charge to build a doctoral level research program, alter the profile of the university, and grow enrollment. In the recasting of the university's identity, feelings were hurt and relationships were tarnished.

It appears as though Dr. Mack may have experienced less conflict with males than females. In college, she had a fractious relationship with her female Latin department head and bonded with her male chemistry department head. She had very good relationships with Dr. George Pond at PSU and Dr. John Guinn at TWU, though she would frequently challenge Dr. Guinn. She and George Vose, though they experienced some conflict in later TWU years, were very close. Dr. Mack and Dr. Joe Sherrill enjoyed a positive relationship. Jim Cain also expressed positive emotions, while acknowledging her strong personality. LaRue, as financial officer at TWU, had a good relationship with Dr. Mack. Bill Stover thought very highly of her, though he too experienced conflict with her. Bill thought that Dr. Mack liked males better than females, because she perceived females to be more conniving. The male in the interview population who expressed the greatest negativity did not have his own conflict with Dr. Mack. His negative feelings derived from Dr. Mack's expectations of his wife while she was one of Dr. Mack's graduate students. The interviewees who had been Dr. Mack's female graduate students acknowledged her conflict with them and/or with other female graduate students.

In looking at the patterns that emerged from the data for this study, some differences were apparent that relate to conflict. In comparing the PSU years with the later TWU years, both control and stringency are revealed as patterns. However, the available evidence regarding these attributes is stronger for the TWU years. Looking at the comparison among data sources, these attributes are more strongly supported by the author interviews and interviews by others. Document data were not as revealing as interview data on these attributes. One possibility is that documents are less likely to portray traits in a negative fashion. The other possibility is that Dr. Mack became more

controlling and stringent without her first degree family relationship support during her TWU years and/or her advancing age influenced these attributes. The answer probably involves a mix of these possibilities.

An interactive examination. The previous discussion of creativity through the person lens is one of the four components of creativity, the 4 P's, which have emerged in studies. In addition to person, the others are process, press, and product. While these components have been examined individually, Moran (2008) takes a systems approach for interactively examining the 4 P's, which she refers to as individual, domain, field, and outcome. In order to focus on the interaction of elements, Moran suggests using the concept of role as a lens. The role, which is the intersection of individual, field, and domain demands, provides the potential for creativity to occur. Dr. Mack's creativity can be examined using Moran's interactive model and role as a lens.

Creativity involves the influence of the individual on the domain in its impact on the thoughts or behaviors of others. In the individual-domain interaction, Dr. Mack developed areas of study. She changed the perspectives of others, not only on the content of the work that was studied and researched, but on the methodologies as well. Her Pennsylvania Mass Nutrition studies evidence this, with the type and scope of data collection and the use of her original bone density methodology. In field-domain interaction, Dr. Mack in her role exerted a similar influence in changing the perspectives of others through the methodologies and results of the massive quantity of innovative research she, her students, and colleagues conducted at PSU and TWU in the areas of textiles and nutrition. Dr. Mack's communication skills and drive to get research results published and/or presented provided a pipeline from domain to field. The field

responded, with adjustments in the field-domain alignment. For instance, in the 1930s there was a need for valid techniques to appraise the nutritional status of humans in order to improve poor dietary practices. No laboratory had formed an extensive battery of tests to evaluate human physical status as it related to nutrition. Dr. Mack's longitudinal study influenced the domain. This novel work was considered creative by the field and influenced the way that human nutrition was studied.

Dr. Mack's role encompassed her predictable behaviors, dependent on her knowledge and beliefs, and her social context in terms of identity and power in relationship to others. In her role, it does not appear that Dr. Mack ever perceived herself as subordinate to anyone. Even President Guinn at TWU was not spared the force of her personality in pursuit of the goals at hand. It was a rarity to have a female at TWU with her power, and she used it to influence her domains, which influenced her fields. Dr. Mack also had a real understanding and true belief that women should be able to excel in careers as men did. In her role, not only did she change perspectives on research parameters and the nature of her domains and fields, she changed women's perspectives on their roles and what they could accomplish. In the process, she managed to change the perspective of the field on what a "girls' finishing school" could bring to the field through innovative research. In Dr. Mack's time and place, her creativity could be considered an aberrant role typology. Her gender-free perspective, extensive knowledge, ambition, and unshakeable confidence produced results that expanded her role, which led to greater results. Dr. Mack did not fit the expected complementary role of women that existed at that time. Instead, she exhibited the strength, competitiveness, and decisiveness of the male role. Moran's concept of role, a systems model, is reflective of the

psychobiosocial model. While we can examine isolated elements for greater understanding, nothing is every quite that independent and simple.

Gardner's creativity framework. Dr. Mack's traits and behaviors show some relationship to Howard Gardner's creativity framework (1993) presented in Chapter II of this study. Gardner's framework derives from the relationship among three fundamental elements. The first of these is the individual both as child and master. Gardner makes the case for a special combination of the childlike and the adultlike as a significant attribute of creativity. Similar to Einstein, Dr. Mack had an insatiable curiosity, reflective of the *"Why?"* question continually asked by young children. Dr. Mack, like Picasso, also had a strong desire to control.

The second element of Gardner's framework involves the work and domain the individual engages in and affects. Dr. Mack mastered her domain, evidenced by her national prominence a decade after beginning tertiary studies. Her work at PSU during this decade involved development of a chemistry program for women. In this period she also instituted the study of Textile Chemistry and built it into a domain for graduate work. Fifteen years into her career at PSU, she undertook the Pennsylvania Mass Nutrition studies, changing the lay perspective of bone and providing the first in-depth longitudinal study of human nutrition utilizing a methodology she invented. Her pioneering research changed the nature of her domains in the areas of nutrition and textiles. Her affect on her domains was evident over the course of her lifetime, continuing during her latter decades at TWU and her involvement in the NASA studies.

The third element of Gardner's framework involves the other people in the individual's world. Dr. Mack's maternal relationship was a significant factor in her life.

Beyond her mother, though, she did not have other strong maternal figures in her life. She benefitted from relationships with males. In some of these relationships, particularly early ones, she engendered support while not in a dominant role, including those with Dr. Schlundt at Missouri State University and Dr. Duncan and Ernest Axman at PSU. Many of her relationships that provided support are indicative of her strong personality and suggest she was the dominant party, including her relationships with her husband and Dr. Guinn. Gardner's population also experienced turbulent relationships with others. Dr. Mack did as well, which is evident in the previous discussion on conflict, the challenges to her work and methodologies, and the interplay of her gender with time and place. In line with Gardner's perspective, Dr. Mack's creativity grew out of her relationship with the objective world of work and her ties with other humans.

Ten-year rule. The ten-year rule examined in Chapter II suggests that in many fields of endeavor, significant creative outcomes are not produced before 10 years of work and study in a domain. Many of the creative individuals studied by Gardner evidenced this pattern. In Dr. Mack's chronology of events, summarized in Appendix F, Dr. Mack's national prominence for research on synthetic textiles emerged about a decade after she initiated study at Missouri State. A decade after coming to PSU, Dr. Mack began her doctoral research. A little more than a decade after beginning her doctoral research, the Ellen H. Richards Institute was established at PSU to house the massive numbers of studies being conducted by Dr. Mack, her students, and staff. A decade after the Institute was created, Dr. Mack took on Guinn's challenge to recast TSCW into a premier research university. Another decade later found Dr. Mack creatively skirting mandatory retirement age and tackling the NASA studies in unique

ways. At the end of this decade she received the Silver Snoopy Award from NASA. A case could be made for the existence of the ten-year rule, though the argument could shift a bit in terms of the actual number of years. Dr. Mack's initiation of the Pennsylvania Mass Nutrition studies, a significant creative endeavor, began about fifteen years into her studies and work. Regardless of the exact time frame, it does appear that Dr. Mack exhibited a number of regeneration cycles. Her patterns suggest the importance of widespread domain-specific knowledge and purposeful practice for success discussed by Gorny (2007).

Exit strategy. In Chapter II, Zhou and George's (2001) research on job dissatisfaction was examined. They wanted to know whether job dissatisfaction could positively impact organizational effectiveness and what conditions would result in creativity as an expression of voice. Voice was identified as one of the four ways in which employees respond to job dissatisfaction. Voice is an active strategy in which the dissatisfied employee determines to remain with the organization and engage in endeavors to improve conditions. With high job dissatisfaction and high continuance commitment, the greatest creativity occurs under the presence of one of the following: (a) helpful feedback from coworkers, (b) assistance and support from coworkers, or (c) when perceptions of organizational support for creativity are high. During her career at PSU, Dr. Mack benefitted from assistance and support from coworkers. She had support and encouragement for her creative endeavors, such as *The Chemistry Leaflet*, from Dr. Frank C. Whitmore, during his tenure as head of the Department of Chemistry at PSU. Though not always a smooth path, she had the opportunity to develop programs of study and build the Ellen H. Richards Institute.

Dr. Mack's continuance commitment eventually weakened. The totality of causal factors is not known. However, George Vose spoke of Dr. Mack's unrealized dream of having a brand new research building. She had to make do with older facilities retrofitted for her work. Dr. Mack, in a report to George Haller, the new dean of the School of Chemistry and Physics at Penn State, revealed her dissatisfaction. Dr. Mack stated that she decided to spend the remainder of her productive years in a more conducive environment as regards space and the absence of internal competition. Dr. Mack appeared to have a negative perception of organizational support for her creative endeavors and less than desired supportive collegial relationships. These factors may have contributed to her engaging in an exit strategy, in which she determined to leave Penn State for the creative challenges and perceived support of Dr. Guinn at TSCW.

Leadership

Relevance of trait theory. Leadership was examined from various perspectives in Chapter II of this study. While a number of studies have discounted a trait approach, the resurgence of trait theory presented by Kirkpatrick and Locke (1991/1995) offers a productive lens in which to consider Dr. Mack's core traits as contributing factors for leadership success. Kirkpatrick and Locke found evidence showing that there is a difference in six traits between leaders and non-leaders. They believe that the individual does matter and the right stuff needed by leaders is not equally possessed by all individuals. Did Dr. Mack have the right stuff?

The first of the necessary six traits is drive, which reveals a high degree of effort and incorporates achievement motivation, ambition, energy, tenacity, and initiative. Dr. Mack possessed an incredible drive. She was known as a real go-getter, often calling

her researchers into the lab in the wee morning hours. Her professional work was a primary consideration for her, to the point of postponing her marriage for four years in order not to disrupt her work. Dr. Mack's work was her life. She persisted with an unbelievable tenacity, finding a way to get the jobs, the funding, and the people to get the jobs done. Dr. Mack seized the initiative, always managing to get into new fields. She did not wait for opportunities to come her way- she made them.

A desire to lead, which includes motivation to influence others and may involve a need for power, is the second requisite trait. Dr. Mack's desire to lead is obvious. She was known as a person who wanted to direct everyone. She was in charge and took command, wanting things done her way. Her motivation to influence others extended into many realms. She was tenacious in her endeavors to influence young people to understand, enjoy, and engage in the pursuit of science. Dr. Mack was highly motivated to influence industry to step up to the plate to provide accurate information for consumers. Over the course of her lifetime, she was motivated to carry out her own women's liberation movement. She was driven to influence females and minorities to overcome the perceptions of their era to achieve their highest potential. Dr. Mack was incredibly adept at influencing others to fund her research endeavors and was unrelenting in utilizing her influence to further those endeavors. It is not apparent that she ever considered herself subordinate to anyone, even Dr. Guinn.

Honesty/integrity, with correspondence between words and actions, is also seen as a necessary factor. This is an interesting trait as it relates to Dr. Mack. In examining her work, great congruence is seen between her words and actions. She talked her way into the jobs and related financial support, and she also delivered, frequently more than

promised. Dr. Mack adhered to the highest standards and expected others to as well. When she offered assistance to students, she kept her word and devoted untold hours to helping them. However, at least a few individuals found her to be manipulative in nature, pulling out all the stops to get them to do what she wanted or needed them to do. Trust was broken with a few over the course of her career.

The fourth necessary attribute is self-confidence, which is important to decision making and earning the trust of others. Early in Dr. Mack's career at PSU, one of her students noted that her appearance of capability was one of the keynotes to her personality and character. Dr. Mack was highly confident, believing she was right. No one could intimidate her. She was unfazed by the perspectives of others and pursued her work in the face of naysayers. This was evidenced in her pursuit of bone density research when others initially scoffed at this and her adamant stance regarding the health hazard of lead weighting in spite of research to the contrary. No challenge, whether it involved developing programs of study, building a research program, or assailing industry practices, seemed to faze her. She would tackle anybody and anything and everyone knew it. Dr. Mack was decisive. In spite of hurt feelings at times, most of her colleagues and students trusted in her support and ability to accomplish the task at hand.

Cognitive ability, required for the analysis and synthesis of large quantities of information, is the fifth needed attribute. Dr. Mack's brilliance is referenced in all contexts and by all sources. Precocious as a child, she was acknowledged as still an intellectual giant in her 80s. Her intellect is visible in her vast body of research and publications, her innovative methodologies, the programs she built, and her enjoyment of scholarly things. Dr. Mack was referred to as being an honest genius. On top of this, she

had the ability to get things done even if she didn't know how to do them herself. The probing, productive mind of the woman with equal parts brains, style, and chutzpah continued in high gear until almost the very end of her life, when illness finally prevailed.

The final attribute discussed by Kirkpatrick and Locke (1991/1995) is knowledge of the business, which is needed to make informed decisions and comprehend their implications. Dr. Mack was a lifelong learner who kept abreast of the latest developments. She was one of those people who were driven to know. It was considered a privilege to be able to study with her. One could learn from her just by being in her presence, given her incredible wealth of knowledge. Dr. Mack was positioned at the forefront, perceiving opportunities and capitalizing on them. One can presume that her significant knowledge base supported her vision. Dr. Mack recognized the cradle-to-grave implications of the quality of nutritional intake. Her knowledge base supported her invention of the methodology and pioneering use of X-rays to monitor changes in the bones of living subjects. Dr. Mack was known as one of the all-time greats in her field, providing leadership for the advancement of knowledge.

Behavioral theory consideration. Dr. Mack exhibited the six traits considered as contributing factors and preconditions for leadership success. These conditions are not sufficient in themselves, as leaders need to act in order to be successful. The data from this study suggest that Dr. Mack fell on the task-oriented side of the task-relationship continuum. Task-oriented leaders focus concern on task outcomes. Their behavior is typically more structured, directive, and perhaps autocratic. Dr. Mack knew what had to be done, wanted it done her way, and wanted it done correctly and quickly. It was noted that she had a weapon for every occasion. People deferred to her and did it her way. They

could challenge her, but as Bill Stover noted, they had darn well better be right. While Dr. Mack was highly focused on production, it does not mean that she didn't vary on the task-relationship continuum. She exhibited concern for her employees and students, supporting them financially and through growing their capacities. She provided social interaction opportunities and recognition of outstanding students. Thoughtful gestures, such as sending flowers to sick employees and students, and hosting weddings and baby showers, were considerate behaviors. However, she was not one to avoid conflict and the evidence does not suggest participative, consensus decision making.

Transactional versus transformational leadership. In examining Dr. Mack's leadership from the transactional versus transformational lens, one can find evidence of both. Transactional leadership is particularly evident in Dr. Mack's Texas context. Having relocated to a new environment, without the substantial support of her parents and husband, Dr. Mack utilized a transactional style to bridge her highly stressful neutral zone. Dr. Mack exchanged room and board and leadership through the research process for companionship and domestic support. Her relationships with the graduate students that lived with her were reciprocal in nature. With her staff members in Texas, Dr. Mack expected long hours on the job, with work done to her exacting standards. Her employees provided competence and loyalty. In exchange, she fought for compensation for her staff that was often above what other TWU employees were receiving. Her employees also had status and influence. There was a sense of urgency and pride in their work on the NASA space studies.

Evidence of transformational leadership would indicate that Dr. Mack and others engaged with each other in ways that elevated her and them to higher levels of motivation

and morality. Transformational leadership can be seen in Dr. Mack's interaction with students and employees that altered the perspectives of what they could accomplish and the nature of their roles. In these interactions, persons were motivated to greater levels of achievement. They were also motivated to move beyond the constraints of stereotypes and role expectations to fulfill their potential. Dr. Mack's transformational leadership is evidenced in her work with others to advocate for and inform the general public and in researching and developing plans to address the nutritional needs of individuals in constrained circumstances. It is evidenced in the work that led to reduced institutional laundering costs in Pennsylvania and Texas.

Context. Individuals are complex, with traits and behaviors intertwining with time and place. Dr. Mack provided leadership for the advancement of knowledge in an era when it was rare to find women in leadership positions. She learned, lived, created, taught, and led in a male-dominated field and culture. Akin to the psychobiosocial model and the interactive framework for examining creativity that are dynamic in nature, Dr. Mack's leadership is a function of time and place. Her attributes and behaviors influenced and were influenced by her place in history.

Rosener (1990/1995), in a survey described in Chapter II of this study, found that male respondents were more likely to describe themselves in a manner suggestive of transactional leadership, while female respondents tended to self-describe in a manner more suggestive of transformational leadership. The data for this study place Dr. Mack on the transactional side of this continuum. It is intriguing to look at Dr. Mack's leadership behaviors and traits in accordance with her role and context. Rosener points out that the first generation of female executives emulated many of the behaviors and

traits that were successful for men in leadership positions. Prior to the 1960s, women were expected to be in supportive and complementary roles. Men were expected to display strength, competitiveness, and decisiveness, all of which describe Dr. Mack. Those who knew Dr. Mack refer to her masculine attributes and gender-free perspective. In fact, when it was noted to Bill Stover (Pyle, 1993) that Dr. Mack was female, his response was, “Oh, no, she wasn’t female!” Further questioned on how Dr. Mack viewed herself, Stover’s response was, “Uh, just whatever the occasion called for.” Dr. Mack dealt with challenges pertaining to her gender, which will be discussed later in this chapter, and battled to get what she wanted. Under these circumstances, it is possible that Dr. Mack capitalized on what were considered masculine attributes, either purposefully or intuitively, in what could be considered masculine leadership behaviors, whenever it was necessary to accomplish her goals. On the flip side, as Stover indicated, she demonstrated a feminine side when necessary. Complex, charismatic, and a chameleon, Dr. Mack was a study in contrasts.

Goldberg’s findings from his interviews of educational leaders (2001) indicated that though leadership varies in form and possesses multiple characteristics, five qualities are readily apparent. Dr. Mack’s leadership evidenced those qualities, which are reflected in the prior examination of her leadership. She held a *bedrock belief* in the potency and utility of her undertakings. She believed we needed to improve nutrition as a civilization and also believed that women should be able to excel in careers as men did. She had the *courage to swim upstream* for the sake of her beliefs regardless of the barriers. Dr. Mack would take on anything and anyone, finding a way to accomplish her goals. If one avenue was blocked, she would find another. If her universities could not or would not provide

the necessary funds or equipment, she would persevere until alternative sources were secured. Dr. Mack possessed a very strong *social conscience.* She was concerned with recruiting and engaging minorities and assisting them in succeeding academically. Dr. Mack was very concerned about the effect of poverty on nutritional status. Her research and plan to utilize school lunches to fill in nutritional gaps evidence this. She was concerned with the education and improvement of women. Dr. Mack also possessed a *seriousness of purpose*. She had incredibly high standards and devoted lengthy service to her causes. Her work and its quality were her life in service of leadership for the advancement of knowledge in the areas of food, clothing, and shelter. From the moment she switched to her chemistry major, she was driven on a trajectory that only ended when illness prevailed at the very end of her life. Lastly, Dr. Mack also had *situational mastery*, or congruence of her personal skills with the work to be accomplished. Her intellect, knowledge, ambition, persistence, and other attributes were highly congruent with the development of new areas of study. She had both the knowledge and the fortitude to effect large-scale changes in an era not known for women in leadership positions.

Goldberg (2001) is of the opinion that situational mastery is the specific factor that impedes identifying a generic set of characteristics defining what is needed to be an educational leader. Leaders, their skill sets, and their contexts are not interchangeable. Congruence between the leader and the necessary work is critical. Dr. Mack had the skill set, the equal parts brain, style, and chutzpah, congruent to the work to be done in her time and place.

Transforming Junctures

Continuing to build knowledge for addressing the instrumental aspects of this study, the third guiding question addressed what, if any, transforming moments or epiphanies were revealed in the examination of Dr. Mack's life story. The evidence will be considered in chronological order.

Positioning Transformations

Dr. Mack may not have recognized it at the time, but the first significant transforming moment in her life discerned in the available data would be her change of major at Missouri State University. At odds with the Latin spinster department head, her success in chemistry put her on a path from which she never wavered. Science and research provided fertile ground that could support Dr. Mack's lifelong needs for intellectual growth, challenge, and novelty. This turn of events supported the development of her *situational mastery* and resounding successes. From Collins' perspective (2001), this change of path situated Dr. Mack to be able to take the right seat on the right bus. In Dr. Mack's case, this would turn out to be the driver's seat!

The second transforming moment of Dr. Mack's life was her recruitment and acceptance of Dr. George Gilbert Pond's invitation to come to PSU. In spite of Pond's death shortly after her arrival at PSU, Dr. Mack was now in an environment in need of and conducive to the development of new programs and avenues of research. Though she faced some obstacles and opposition in this environment, PSU was highly conducive to serve as a research crucible capable of supporting the magnitude and type of research Dr. Mack was able to initiate. PSU provided the stage, and Dr. Mack provided the

performers and the performance. In many cases, she also provided the operating funds and equipment.

One could possibly consider that Dr. Mack's meeting and subsequent marriage to Dr. Warren Mack was another transforming moment. This is another instance, like her change of college majors, in which congruence was established. The Macks had contrasting personalities, with strong intellects that engaged each other. Warren Mack epitomized the ideal supportive spouse. He was very liberal, an anomaly in that era, in his support of Pauline's career endeavors. He would have married Pauline under any terms whatsoever, and was accepting of the fact that she had no interest in domestic pursuits. Warren Mack supported Pauline emotionally and practically, contributing his skills to her academic and career endeavors. He took care of the necessities of daily life, their food, clothing, and shelter, freeing her to concentrate on her work. Warren served as an emotional control valve for Pauline. They had an agreement that negative topics would wait until morning to be discussed. In Texas, without his support and influence, nothing was held back.

A Dramatic Breakthrough

Dr. Mack, in the right place at the right time with a high degree of spousal support, had a major epiphany that was rooted in her Ph.D. research. Dr. Mack (1969) was attempting to derive measurements of bone density from X-rays by a process that involved passing a stationary beam of light through stationary X-ray film. She had to abandon this method due to the difficulty of locating exact skeletal areas in the films from one time to the next. Dr. Mack found inspiration deriving from her use of a tracing device for the evaluation of the density of lines on a spectrographic plate. This had been

used for analysis of colored glass filters in her study that was designed to find the relation of radiation from different parts of the spectrum on growth and skeletal status in rats. This epiphany led her to adopt a scanning method for the evaluation of bone density from radiographs.

Dr. Mack, with the help of her husband, built the first instrument in the early 1930s. They purchased a Type B Moll Recording Microphotometer to use as a potential basic piece of instrumentation for the intended device. This proved to be unsatisfactory. Following extensive redesign and rebuilding, Bone Densitometer I emerged. The only parts of the original Type B Moll Recording Densitometer included in this instrument were a Coblentz galvanometer and the accessory photographic system that recorded tracings. Four reports on the Pennsylvania Mass Nutrition Studies, published from 1940-1942, contained the first data on bone density derived from Dr. Mack's scanning method. Dr. Mack's breakthrough was produced approximately two decades after she began her studies and work in chemistry, physiology, and mathematics at Missouri State University. Crude by today standards, this device is the ancestor of the bone density units currently in use.

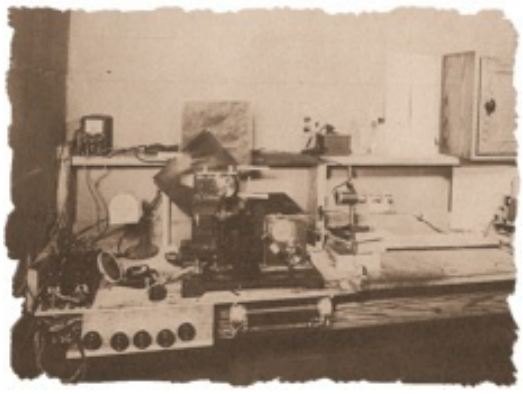


Figure 20. Densitometer, PSU, sub-basement of Osmond Laboratory, 1942. Photo courtesy of George Vose.

Change of Venue

Dr. Mack lost her parental support system with the death of her father in 1944 and the death of her mother in 1946. She lost her supportive dean, with Frank Whitmore's death in 1947. The combined loss of these support systems and her receipt of the Garvan Medal in 1950 may have contributed to Dr. Mack's decision to leave PSU. Receipt of the Garvan Medal brought her recognition as the top researcher in her field, just what Dr. Guinn needed to accomplish his goals for TSCW. Accepting his challenge to recast TSCW as a premier research institution meant significant change in her life. This transformational event was then compounded by the traumatic, unexpected death of her primary support system and soul mate, Warren Mack, right before the final move to Texas was to take place. This chain of events led to the most significant transformational period in Dr. Mack's life.

Dr. Mack went through a very difficult period upon her arrival in Texas. Many individuals in her new context did not see through her strong personality to the depth of her grief. One of the students who lived with her developed perspective over time that her light had gone out- there was no flicker. Dr. Mack was handicapped without Warren, the person who had attended to the demands of daily living, engaged her intellectually, and supported her emotionally. She was devastated by her husband's death. In the midst of all this, Dr. Mack had undertaken a highly ambitious challenge to transform TSCW into a premier research institution, including the challenge to bring in the funds, the work, and the students. Dr. Mack gradually compensated for her losses, and with help from some of her graduate students, learned to enjoy life once again. She recovered and carried on, delivering on her commitments to Dr. Guinn. Though she helped put TWU on the map,

her years in Texas were not her happiest ones. Jean Sherrill believes that Dr. Mack would never have chosen to move to Texas had she known her husband would not be accompanying her. Throughout her years in Texas, Dr. Mack spoke of Warren with adoration, love, and respect.

The Space Age

Successful as a change agent in Texas, another transforming moment occurred when Dr. Mack had the foresight to connect the nutrition and bone density research being conducted at TWU with issues relating to calcium loss during manned space flights. TWU was not even considered as a potential site for NASA calcium studies, and was not included on the original list of possible colleges and universities. Dr. Mack, obtaining an opportunity to submit a proposal, was able to sell TWU's program of measuring calcium density through X-rays. She served as the Principal Investigator on the NASA studies while in her 70s. The studies brought funds, recognition, energy, and excitement to the TWU campus. TWU's profile was raised. Employees, students, and study volunteers were caught up in the sense of urgency regarding their work and contributions. Her Denton community valued her and accepted her idiosyncrasies. Dr. Mack achieved her goal of proving that TWU was much more than a girls' finishing school.

Closure

The final transforming event of Dr. Mack's life is found in her struggle to keep working and to not succumb to the eventualities of illness and age. She fought hard not to give in, being brought into work at the end of her life in her wheelchair. One can presume that the separation from the work she loved was a bitter blow. It is a credit to Dr. Guinn that he did everything possible to support Dr. Mack during this time for as long as it was

feasible. She had accomplished all he had asked of her and more and he strove to cushion her inevitable departure.

Educational, Career, and Life Challenges

In consideration of concerns related to engaging, educating, and retaining individuals in STEM fields, the fourth guiding question of this study pertained to what, if any, educational, career, and life challenges were experienced by Dr. Mack that were associated with stereotyping, gender, bias, or other issues revealed by this study. If there were challenges, the author looked to determine how Dr. Mack addressed them and how those challenges might have influenced her decisions. The data were also examined for evidence of any mediating factors that might have supported successful handling of identified challenges.

The first identifiable challenge revealed in the data is Dr. Mack's conflict with the female Missouri State Latin department head. This conflict and Pauline's subsequent medium grade could have terminated her stay at college. Pauline's unhappy mother had them packed up and ready for departure. Though the cause of the conflict is unknown, the fact that Pauline referred to the Latin department head as an acid-tempered spinster suggests a personality clash with the fun-loving, humorous student. The challenge was mediated in part through the support of the male chemistry department head, who teamed up with Pauline to persuade her mother to give her another opportunity. Pauline's intellect and stellar performance in chemistry, combined with her persuasiveness and ability to charm, probably garnered Dr. Schlundt's support.

Dr. Mack also faced a challenge that probably related to bias, stereotyping, and her gender while employed as the science department head at Webb City High School. In

this instance, Pauline was denied her raise by her male principal. Pauline had purchased a dress made from the new rayon synthetic fabric so that her chemistry students could see what the new fabric looked like. Her principal did not recommend her for a raise because she obviously didn't need one. His rationale was that anyone who could afford the luxury of an expensive dress certainly was not in need of an increase in salary. With a severe dent in her continuance commitment, Pauline met this challenge by developing an exit strategy and moving on to Springfield High School. Accepting this position provided another challenge, as she was recruited by Dr. Pond from PSU after signing a contract at Springfield that the school board would not vacate. Pauline fulfilled her contract, completed her master's degree at Columbia University, and then headed to PSU.

Bias, stereotyping, and gender were roadblocks to pursuit of Dr. Mack's desired career. She wanted to go into pure chemical research, but found it to be a man's field. She turned to the application of chemistry to medical, household, and industrial problems, creating her own programs and research empires. Following Dr. Pond's death, Pauline encountered frequent opposition while creating the program Pond had intended for her to create. Minus his support and with opposition, she met this challenge through sheer perseverance. Mediating factors include the support that Pauline had from her husband and her friend, Mary Willard. Both contributed to her textbook, first published in 1923.

Dr. Mack also faced challenges in becoming Dr. Mack. After the departure of Dr. Honeywell, her dissertation advisor, Dr. Honeywell's successor expended a great deal of energy and ingenuity in discouraging Pauline from her doctoral studies. Also, more than one individual interfered with her research by turning on lights that were supposed to be kept off. Pauline persevered, finding sympathy and help from Dr. David Duncan, a

member of a different department. She also engaged the help of Ernest Axman and her husband. Even Pauline's mother pitched in, helping her with her manuscript. In what appears to be tinged with bias, stereotyping, and gender issues, some of Dr. Mack's male colleagues persisted in calling her Mrs. Mack after she had earned her doctorate. It is not evident what Pauline's response was to this show of disrespect. Perhaps she let her work speak for her.

It is interesting to note, while not exactly a barrier or challenge, that the Garvan Medal received by Dr. Mack served a compensatory function. It was not until 1967 that a woman was honored with any other ACS prize. Dr. Mack, while highly honored for a woman of her time, would most likely have received the greater recognition that others thought she deserved in our later time in history.

Dr. Mack cited a lack of space and internal competition as two factors contributing to her decision to leave Penn State. The data for this study do not yield more regarding these issues. Pauline did talk with George Vose about the impediments presented by being female and having to battle to get what she wanted. It appears that she met this challenge by engaging in another exit strategy to segue to TSCW, an environment she perceived would be more supportive during the remainder of her productive years.

Dr. Mack's age was a looming obstacle as she approached her 70th birthday. TWU had a mandatory retirement age at that time. She was in no way ready to stop working. Pauline met this challenge by crafting a creative solution. She retired from her administrative position, ostensibly to focus on increased research demands. Research funding came from grants and other sources. Those same sources could pay Pauline's

salary outside of TWU's employee payroll. It was a win-win situation and Pauline was able to provide another decade of productive service to the University.

Another obstacle faced by Dr. Mack was the perception of TWU as a girls' finishing school. She tackled this one by the scope, quality, and innovation of her research programs and her ability to publicize the work taking place. Dr. Mack's charisma brought in the work, the funds, the students, and the press. She was effective in her influence of the Legislature and others with money, power, and connections. Dr. Mack sold her methodology and secured the NASA contracts. During this period, she was constantly bombarded by people that didn't believe in the work they were doing and how good she and they were. She had to defend her work multiple times in Washington, which she did with success. Her perseverance in these endeavors was relentless. Perseverance, confidence, networking skills, communication abilities, ambition- Pauline's attributes provided a formidable combination to meet and overcome practically all challenges. Unfortunately, all of these attributes could not sway the rigidity and biases of the United States Navy.

One of the most painful barriers in Dr. Mack's career took place during her work on the NASA studies. Dr. Mack served as Principal Investigator and was heavily engaged in directing and participating in these studies, to the point of providing a home for one of the monkeys until that proved unwise. Dr. Mack's methodologies were utilized for the studies, she fought for and earned the contracts, and she directed the work. However, she was prevented from fully carrying out her research because of her gender. At the time, it was thought that astronauts needed to be X-rayed as soon as possible after splash down. Researchers would be on board the carriers to conduct this portion of the study. During

this time in history, women were not allowed on board carriers. Dr. Mack was intent on being able to see her work to culmination, but gave up when the threat was made that TWU's contracts with NASA would be cancelled rather than let her on board. It is a highly regrettable aspect of our history that Dr. Mack missed a key experience in her professional life because she was a woman. This was one obstacle she could not overcome.

Perception of the Field

The fifth and final research question to be considered in this chapter deals with how the field perceived and recognized Dr. Mack and whether or not there is evidence in retrospect to corroborate or refute the perceptions of her time. The data utilized in this study, viewed through prevailing sentiments regarding scholarly productivity and Diamond's (2006) framework presented in Chapter II, provide substantial evidence to address the perspective of the field in Dr. Mack's case and corroboration of those perceptions.

Multiple Lenses

Scholarly productivity. There is a prevailing view that to be a scholar, one needs to be a researcher with publication as the primary metric to measure scholarly productivity (Boyer, 1990). While endlessly debated, publish or perish continues to be alive and well today. Dr. Mack was a prolific writer, authoring two books, one of which was a textbook. She wrote more than 200 scientific papers and was coauthor of many research studies and reports. Some of these papers are referenced in Chapter IV of this study. Her scientific papers encompass her many research interests, including applications of chemistry to both foods and textiles. The body of Dr. Mack's scholarly

publications is impressive in size and scope, supporting the view of her time that she was a scholar.

Research grants. Success is also measured by the research grants attained by the scholar. Dr. Mack was highly successful in obtaining grants from diverse sources to support research in Pennsylvania and Texas. She attained so many grant-funded research projects that PSU created the Ellen H. Richards Institute to consolidate the research under one umbrella and Dr. Mack's direction. Dr. Mack attained funds from the Pennsylvania Department of Health, the Texas Legislature, businesses, organizations, and private individuals. She secured grants from the Cotton Research Committee of Texas and NASA. Over the course of her lifetime, she identified productive areas of research, developed the proposals, secured the funding, and delivered the results. The general public, her universities, colleagues, employees, and students benefitted from her productivity and scholarship in this area.

Combining process and product. Diamond (2006) offers a framework that combines process and product to depict the scholarly work of faculty. In order to be considered scholarly, a high level of discipline-related expertise must be required by the work or activity. Dr. Mack's research in food, clothing, and shelter, involving everything from the colorfastness in textiles to food and fiber studies on cotton plants to the loss of bone calcium and phosphorous resulting from inactivity, demanded her very high level of discipline-related expertise.

According to Diamond (2006), the work or activity also must be undertaken in conjunction with clear goals, adequate preparation, and appropriate methodology. Dr. Mack excelled at knowing and articulating her goals. Preparation for studies was

extensive, reflected in the description of the extended bed-rest studies in Chapter IV. Dr. Mack was meticulous and innovative in her methodologies, using equipment that she designed to achieve her goals.

Diamond (2006) also speaks to the need for appropriate documentation and dissemination of the work or activity and its results, with the accompanying need for reflection on the significance of the work, the methodology followed, and the outcomes. Dr. Mack's prolific scholarly publications, previously referred to, meet this criteria. Dr. Mack was very thorough in presenting and reflecting upon the varied aspects of her research. She was also highly demanding when it came to her students' documentation of their work in their theses or dissertations.

Diamond (2006) notes that the work or activity needs to have significance beyond the individual context, breaking new ground and able to be replicated or elaborated. Much of Dr. Mack's work was ground-breaking and replicable, including the type, scope, and magnitude of her longitudinal nutritional research. Multiple follow-ups to her nutritional studies have been done, one that is currently in place. Dr. Mack's densitometer is a predecessor of the bone density units in use today. Her ideas pertaining to environmental issues and energy appear prescient, as do her concerns for the impact of nutrition on humans over the course of their life spans. Even Dr. Mack's *Chemistry Leaflet* has captured attention in the 21st century, stimulating the desire for replication in a modern, technologically supported format. In the area of textiles, we now have the standards and labels so vigorously sought by Dr. Mack.

Finally, Diamond (2006) purports that the process and product or results of the work or activity need to be examined and judged as meritorious and significant by a

panel of the candidate's peers. Dr. Mack's work was judged as meritorious and significant by her peers on many occasions. Such judgment is reflected in her election to membership in the elite Phi Beta Kappa Associates, her fellowships in the American Institute of Chemists, the American Association for the Advancement of Science, the Society for Research in Child Development, and the American Public Health Association. Dr. Mack was also elected to the Society of Chemical Industry in Great Britain and to the Royal Society of Health. She served as a member of the advisory committee of the *Journal of Home Economics*, was a member of the Committee on Rayon Standards of the American Standards Institute, and a member of the Excerpta Medica abstracting service. In addition, Dr. Mack received numerous honors for her work. Among these were the Distinguished Daughters of Pennsylvania Medal, the Garvan Medal of the American Chemical Society, the Piper Professor Award in Texas, and the Silver Snoopy award from NASA. Dr. Mack was the first woman honored as a Priestley Lecturer and also was a lecturer on the program of the Twelfth International Congress of Pure and Applied Chemistry.

Good work. Dr. Mack's success can also be viewed through aspects of the good work perspective explored by Gardner, Csikszentmihalyi, and Damon (2001). While it is not possible to question Dr. Mack on the nature of her work and views, some of the answers can be gleaned from the data for this study. Dr. Mack's work was goal-directed, with intents that included growing the knowledge of the general public to make informed decisions and building the capacity of her domains and fields to address issues of food, shelter, and clothing. Her work was particularly directed at concerns relating to the nutritional well-being of humans. Dr. Mack was highly concerned about the nutritional

needs of those who were less fortunate and developed specific research-based proposals to address these needs.

Dr. Mack believed that women should be able to achieve as did men. Her beliefs were reflected in her actions to support women in their studies and work. Dr. Mack was engaged in many endeavors geared to engender women's interest in science. She was able to change perspectives of what women could accomplish. Dr. Mack's drive for equity also prompted her to support minorities in their educational attainment. In multiple ways, her work served the public and elevated those engaged in the process.

Corroboration

Dr. Mack was perceived as a scholar during her time. She earned an international reputation for her expertise. The many areas that she researched and raised the profile on, including bone density research, school lunches to supplement nutritional deficits, undetected heart ailments in seemingly healthy young athletes, fireproofing fabrics, textile industry standards, and cholesterol concerns, to name a few, now have her in their ancestry. Her women's liberation movement, predating the actual one, raised women's expectations for themselves. By past and present standards, Dr. Mack was a successful scholar as judged by her peers and the general public. Her indefatigable pursuit of good work set a high standard for her and those who worked and learned with her. It also sets a high standard for those who follow. It is with regret that the opportunity is lost to ask Pauline the remainder of the probing questions delineated by Gardner, Csikszentmihalyi, and Damon (2001). While the data evidence her successful scholarship, Pauline's frank answers to those probing questions would be highly revealing and fascinating.

Summary

Chapter V provided an interpretive analysis of data for the first five research questions that guided this instrumental case study. The factors that contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science were examined. Patterns and connections to the theoretical frameworks of constructivism, creativity, and leadership evidenced by the traits and behaviors displayed by Dr. Mack were explored. Transforming moments and epiphanies as revealed in the examination of Dr. Mack's life story were presented. Dr. Mack's educational, career, and life challenges were identified and her responses to these were detailed. Lastly, how the field perceived and recognized Dr. Mack, along with evidence supporting this perception in retrospect, were analyzed. Chapter VI summarizes this case study and fulfills the study's instrumental aspects. Answers to the study's sixth and final research question, concerning the study's conclusions and implications for secondary and tertiary educational leadership, are conveyed in Chapter VI.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS FOR SECONDARY AND TERTIARY EDUCATIONAL LEADERSHIP

Summary

Widespread concerns currently exist regarding our nation's ability to attract, educate, and retain talented, diverse individuals in STEM fields. These concerns are exacerbated by globalized competition and critical economic conditions. With these pressing issues in mind, this study was designed to examine the particular case of a female educator and scientist, who lived, learned, worked, and created in a male-dominated field and culture, in order to gain insight for secondary and tertiary leadership in STEM fields. Dr. Pauline Beery Mack, a 20th century educator and scientist, is the subject of this instrumental case study. Dr. Mack and her life story provided the complexities, richness, nuances, uniqueness, and commonalities to yield fertile ground for individuals seeking to address the complexities of effective leadership in the context of the intensely growing demands of the 21st century.

Pennsylvania State University and Texas Woman's University, each home to a significant portion of Dr. Mack's career, have substantial document resources in their archives that were utilized to support this study. The vast array of resources included items such as original works by Dr. Mack and her colleagues, letters, brochures, newspaper articles, journal articles, research papers, press releases, minutes of meetings, personal artifacts, and photographs. Other sources for this study included the books written by Dr. Mack, her *Chemistry Leaflet*, newspaper archives, journal databases, and NASA. Though Dr. Mack died in 1974, the author was able to glean personal insight

through interviewing nine individuals, including two who knew her during her PSU and TWU years. Additional insight was gained by the transcripts of five interviews conducted by TWU for the University's archives.

In consideration of human complexities, multiple literature strands and frameworks informed this study. The dynamic psychobiosocial model provided a framework for examining and interpreting intertwining influences on cognition. Constructivism, as a theory of learning, facilitated a deeper understanding of Dr. Mack as a learner and as a teacher in support of the interpretation of her actions and decisions. Dr. Mack worked in the intersection of her scientific discipline and her role as educator. Creativity, fundamental to discovery or invention in any context, was particularly relevant to understanding and interpreting Dr. Mack's life as it played out in that intersection. Literature on how success is perceived and measured contributed to understanding of the ongoing dialogue regarding the nature of scholarship and interpretive lenses for evidence of Dr. Mack's scholarship. Exploration of the historical perspectives on leadership facilitated comprehension of the contexts in which Dr. Mack lived and worked and offered lenses for interpreting leadership she evidenced. The germane theories, frameworks, and research in these singular areas revealed intertwining relationships and connections that were beneficial for constructing and interpreting Dr. Mack's life story and formulating the implications of this study.

Six fundamental questions provided direction for this study: What factors contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science? What patterns or connections to the theoretical frameworks of constructivism, creativity, and leadership are evidenced by the traits and

behaviors displayed by Dr. Mack? What transforming moments or epiphanies are evidenced? What, if any, educational, career, and life challenges did Dr. Mack experience that pertained to stereotyping, gender, bias, or other issues revealed by this study? Under the umbrella of this question, the author wanted to know how Dr. Mack addressed identified challenges and how those challenges may have influenced her decisions. The author also wanted to know if there were mediating factors that supported successful handling of any challenges. How did the field perceive and recognize Dr. Mack? The author wanted to know if there was evidence in retrospect to corroborate or refute the perceptions of her time. Lastly, what implications do the findings from this research have for secondary and tertiary STEM educational leadership? Questions one through five were answered in Chapter IV's narrative of Dr. Mack's life and Chapter V's interpretive analysis of data. The sixth and final question is answered in this chapter, following summarization of the study's conclusions. In summarizing these conclusions and answering the final question of this study, Emerson's (1876) words come to mind once again: "Old and new make the warp and woof of every moment. There is no thread that is not a twist of these two strands." Twisting these strands offers the potential for deeper understanding so that we can address our current and future challenges.

Conclusions

Dr. Mack's life story unfolded in Chapter IV, constructed chronologically through an interpretive biographical view. Her life story was then interpreted in Chapter V through the various supporting frameworks and lenses presented in Chapter II that were conducive to building understanding of human complexity situated in time and place. Dr. Mack excelled in a male-dominated field and culture, pursuing her work with

confidence and tenacity. The dynamic nature of Halpern's psychobiosocial model (2006) made it a particularly suitable framework for examining interrelated factors that contributed to Dr. Mack's educational and career decisions to engage and persevere in her intersecting professions.

Psychobiosocial Conclusions

Dr. Mack exhibited a biological propensity for learning in science and mathematics, revealing her precociousness at an early age. It is evident that a dominant maternal influence was exerted throughout her formative years. Her mother held very high educational expectations for her and would not settle for less than her best work. Dr. Mack's mother was also a strict disciplinarian who established work expectations for her child when she was very young. Dr. Mack exhibited a consistently strong work ethic, was in fact driven to accomplish, contributing to her great productivity. Dr. Mack's mother also modeled independence as a working woman and in her marital relationship. Dr. Mack emulated these behaviors in adulthood in her very liberal marriage and devotion to her profession. Both of Dr. Mack's parents provided concrete assistance in her work endeavors. Dr. Mack was also able to garner the support of others. Her charismatic persuasiveness contributed to her success.

Opportunity also played a role in Dr. Mack being situated to pursue her profession. Her family had the financial means to support her education, though she worked during her college years. Time and place impacted the positions she was offered. A dearth of males due to war and a shortage of females with her science background offered opportunities. However, her gender was a barrier to pursuing pure research.

The attributes that contributed to Dr. Mack's success as an educator and scientific researcher, her intellect, confidence, nonconformance, ambition, persistence, productivity, and need for control were formulated through her biological predispositions, her learning experiences and their effects on her choices, her interest and enthusiasm for her disciplines, her expectancy of success, and her role perceptions. From her complexities emerged two attributes that contributed greatly to her success that bear further consideration in the implications segment of this chapter. Dr. Mack's confidence sustained her when others doubted her vision and methodologies. Her confidence enabled her nonconformance. Her confidence contributed to her masterful speaking style. Her confidence earned the financial contributions of others that were so crucial to supporting her research. Her confidence earned the respect and attention of her students. Dr. Mack's confidence was a formidable combination with her persistence. She was tenacious in her pursuit of research projects and the resources needed to conduct them. She persisted in her tasks, showing tremendous fortitude. Confidence combined with persistence led to research in nutrition and textiles that advanced her disciplines and the capacity of her fields.

Constructivism Conclusions

Through a constructivism lens, Dr. Mack was a lifelong learner who strove to continually build and reconstruct her knowledge. Her persistence was evidenced here as well as she pursued new developments and continuously interacted with her environment. Dr. Mack demonstrated aspects of constructivism in her engaging, multifaceted style of teaching and her work with students in their ZPDs. Persistence is again revealed in her dedication to getting students where they needed to be, whatever it took. Dr. Mack was

highly successful in improving the quality of work provided to students, as reflected in Schlechty's Working on the Work framework (2002). Her students experienced success with their authentic work, contributing to the research literature and affecting outcomes in industry and other organizations.

Creativity Conclusions

Dr. Mack exhibited a high level of creativity, whether viewed through an attribute-based person lens, a role lens, or through Gardner's creativity framework. She was brilliant, original, articulate, and imaginative. Dr. Mack had an insatiable curiosity and a high degree of motivation. All of these traits can be found in just one of her many endeavors, the Pennsylvania Mass Nutrition Studies. She formed independent judgments, again reflective of her confidence. Her creative solutions to funding and garnering support are also tied to her perseverance. Like many creative individuals, she experienced conflict in her relationships. In her role, Dr. Mack changed perspectives on research parameters and the nature of her domains and fields. She also changed women's perspectives on their roles and what they could accomplish. In contrast to the expectations of her time, Dr. Mack did not fit a complementary role. Instead, she displayed strength, competitiveness, and decisiveness considered to be more reflective of the male role. Her gender-free perspective, extensive knowledge, ambition, and confidence expanded her role, leading to greater results. In accordance with Gardner's framework, Dr. Mack had a special combination of the childlike and the adultlike, manifested in her insatiable curiosity and desire to control. Dr. Mack mastered her domains, and her pioneering research affected both nutrition and textile domains.

Dr. Mack's maternal relationship was a significant factor in her life. Turbulence marked many of her other relationships.

Leadership Conclusions

Dr. Mack exhibited core traits that are considered to be contributing factors for leadership success. The first of these is drive, which also incorporates persistence. Dr. Mack's work was her life. She did not wait for opportunities to drop on her doorstep-she made them. Dr. Mack had a desire to lead. She was also tenacious in her endeavors to influence young people to understand, enjoy, and engage in science. As regards her work, Dr. Mack exhibited great congruence between her words and actions, delivering on her promises. Self-confidence also surfaces as a leadership trait. As noted previously, Dr. Mack was highly confident. No challenge, whether it involved developing programs of study, building a research program, or assailing industry practices, seemed to rattle her. Dr. Mack had the cognitive ability necessary to analyze and synthesize large quantities of information. She also had requisite knowledge that was never stagnant. Dr. Mack was known as one of the all-time greats in her field, providing leadership for the advancement of knowledge.

From a behavioral perspective, Dr. Mack exhibited a greater propensity toward the task-oriented side of the task-relationship continuum. She evidenced both transactional and transformational leadership. As a transactional leader, she provided room, board, and research assistance to graduate students in exchange for companionship and domestic support. Her employees provided competence and loyalty in exchange for higher remuneration, status, and influence. As a transformational leader, Dr. Mack altered the perspectives of students and staff of what they could accomplish and the nature of

their roles. In these interactions, individuals were motivated to greater levels of achievement.

Contextually, Dr. Mack exhibited masculine leadership behaviors whenever it was necessary to accomplish her goals. She demonstrated a feminine side when it suited the occasion. Dr. Mack possessed bedrock beliefs, the courage to swim upstream, a strong social conscience, a seriousness of purpose, and situational mastery. She had the skill set, the equal parts brain, style, and chutzpah, congruent to the work to be done in her time and place.

Transforming Junctures

Key moments in Dr. Mack's life situated her for the career that would support her needs for intellectual growth, challenge, and novelty. Those included her change of undergraduate major, her decision to accept Dr. Pond's invitation to come to Penn State, and her marriage to the highly supportive and liberal Dr. Warren Mack.

Dr. Mack had an epiphany deriving from her Ph.D. research that led to the breakthrough development of an instrument that used a scanning methodology for the evaluation of bone density from radiographs. Support from her husband was a factor in the construction of the instrument.

Dr. Mack's most significant transforming event involved her move from Pennsylvania to Texas after more than three decades at PSU. The deaths of Dr. Mack's parents and her supportive dean preceded Dr. Mack's receipt of the Garvan Medal. The losses and the recognition may have factored in her decision to accept a position at TSCW. The unexpected death of her husband right before their move was to occur led to a very difficult transition period. Dr. Mack overcame her loneliness, crafted a

compensatory support network, and continued to persevere in her work. Gender proved to be a barrier that Dr. Mack was unable to overcome. During her NASA studies, she was prevented from being present on the carriers when the astronauts were retrieved. She stopped fighting this battle when the threat of TWU losing the research contracts was made. Dr. Mack's perseverance kept her working until about a year before her death. Illness and age finally had their say.

Challenges

Dr. Mack had several challenges in her life. These were solved through a combination of intellect, persuasiveness, and willingness to cut ties based on principle. Dr. Mack persevered in the face of opposition, and also engaged the support of others. She had the confidence and perseverance to battle to get what she wanted. Dr. Mack was adept at crafting creative solutions, such as her answer to mandatory retirement age at TWU. She was a master communicator and changed perceptions through her ability to publicize the work taking place. Her charisma attracted work, funds, students, and the press, enabling her to influence the Legislature and others who possessed money, power, and connections. Perseverance, confidence, networking skills, communication abilities, and ambition were a formidable combination allowing her to successfully address most challenges.

Perspective of the Field

Dr. Mack was a scholarly success. She authored more than 200 scientific papers, coauthored many research studies and reports, and wrote two books. She was highly successful in obtaining research grants while in Pennsylvania and Texas. Viewed through Diamond's (2006) framework, she possessed a high level of discipline-related expertise.

Her work was undertaken with clear goals, adequate preparation, and appropriate methodology. Dr. Mack extensively documented and disseminated her work, reflecting on its significance, the methodology followed, and the outcomes. Her work broke new ground and was able to be replicated and elaborated. In addition, her work was judged as meritorious and significant by her peers on numerous occasions.

In consideration of Gardner, Csikszentmihalyi, and Damon's (2001) good work perspective, it can be ascertained that Dr. Mack's work was goal-directed. She intended to grow the knowledge of the general public to make informed decisions. Dr. Mack also strove to build the capacities of her domains and fields to address issues of food, shelter, and clothing. She was greatly concerned with the nutritional needs of those who were less fortunate and developed specific proposals to address these needs. She believed in and engaged in support for women and minorities. In multiple ways, her work served the public and elevated others. Dr. Mack was indefatigable in her pursuit of good work, setting a high standard for herself and those who worked and learned with her and for those who follow.

Implications for Secondary and Tertiary Educational Leadership

Introduction

In examining the data from this study through Halpern's (2006) psychobiosocial model and the mutual influence of psychological, biological, and social variables, it is evident that genetic predispositions factor in our cognitive achievement outcomes. However, psychological and social variables, which can be influenced, affect those outcomes and our biology. The circular dynamics indicate that there is much that we can do to promote positive outcomes to widen the options available to individuals for their

benefit and the benefit of society in general. The interpretive analysis of data from this study suggests several potential areas of focus for secondary and tertiary educational leaders who are concerned with our difficulties in attracting, educating, and retaining talented and diverse individuals in STEM fields.

STEM Valuing: Choice as an Outcome of Interest

The value individuals place on endeavors affects how readily learning occurs. Additionally, the choices individuals make are impacted by the value they place on what they consider their range of options and their perceptions of the likelihood of success in that range. Interest affects our learning, which affects our perceptions of our options and our likely outcomes. Engendering interest becomes an important leadership factor when choice is viewed as an outcome of interest and educational leaders want to increase the perceptions among students that STEM disciplines are viable options for them. The survey discussed in Chapter I (Kadlec, Friedman, & Ott, 2007) indicated that while parents and students are cognizant of the importance of science, mathematics, and technology, most of them consider the subjects not relevant to their personal interests and goals. Educational leaders can do much to increase student interest and value for STEM disciplines, beginning with the consideration of relationship.

Dr. Mack possessed a high degree of interest and enthusiasm for her areas of study, including chemistry, physiology, and mathematics. This interest and enthusiasm was particularly evidenced when her negative relationship with her Latin department head and subsequent medium performance disrupted her pursuit of a Latin major. Her rapport with the chemistry department head, Dr. Schlundt, probably factored in her positive perceptions of chemistry as a field of study. While her cognitive ability matched

the demands of science and mathematics, without interest and the expectancy of success, value for the endeavor declines and the choice is lost.

A potentially productive avenue for educational leaders is to examine the web of relationships that influence interest. Relationships exist among all combinations of these parties: leaders, teachers, students, parents, and individuals in the community and world of work. Each of these relationships has the potential to increase or decrease student interest in STEM fields. Starting with self, the leader can evaluate the nature of her or his relationships in consideration of how those interactions support growing student interest in STEM disciplines. Does the leader engage staff members in discussions, activities, and professional development to build their capacity for positive relationships conducive to growing student interest in their disciplines? Does the leader model interest in and value for those disciplines in relationships with all parties? In what ways does the leader connect with parents and the larger community to facilitate endeavors that will enhance student interest? Every relationship offers the potential for modeling STEM valuing and interest.

In the relationship building process, it is also beneficial for educational leaders in secondary or tertiary settings to develop specific knowledge of what takes place in the classroom. For the leader of a department, school, or university, reflecting on practices regarding the leader's classroom visits, conversations with students, and careful reading of student evaluations can be illuminating in evaluating one's degree of cognizance regarding what is being modeled for students. This knowledge offers a foundation for meaningful conversations to bring greater recognition of the power of positive relationships in the pursuit of learning.

Dr. Mack was highly committed to reaching out to students to foster their interest in science. She utilized various media of the time, including radio broadcasts and her *Chemistry Leaflet*. In these outreach endeavors, she provided fascinating information and connections that established relevance for the topic of study. Her timely *Leaflets* paralleled the secondary curriculum of the era and added much-needed spice. Dr. Mack also guided the development of the Student Science Clubs of America, which sponsored a series of broadcasts on science in daily life. In one of these broadcasts, Dr. Mack purposefully inquired whether girls should choose science as their profession. Dr. Macy, a guest on the show, remarked that before choosing science as a field, girls should make sure they have an interest in the subject which will prevent them from being talked out of tackling it as a lifetime's job. Dr. Mack, well-aware of the importance of interest, put her many talents to work to develop this interest. She reached out to high school students and she was also involved in programs for teachers, building their skills and piquing their interest in new developments. In addition to "in-house" efforts to strengthen interest in STEM fields, collaborative endeavors between secondary and tertiary institutions can be mutually beneficial. Technological developments of the 21st century provide many new avenues for today's educational leaders to utilize in outreach efforts.

Discipline-Related Expertise

The ten-year rule discussed in Chapter II indicates that in many fields of endeavor, significant creative outcomes are not produced before 10 years of work and study in a domain. A similar pattern was evidenced by Dr. Mack. Dr. Mack's depth of knowledge was greatly respected by even those who disliked her. It was considered a privilege to study with her, and individuals learned just by being in her presence. Depth

of knowledge in a domain has ramifications for outcomes and is also a factor in one's confidence, expectancy of success, communications, and interactions with others. Knowledge is needed to make informed decisions and comprehend their ramifications.

There are multiple implications for secondary and tertiary educational leaders with regards to the important consideration of depth of knowledge. First and foremost is in the careful selection of staff members who have a considerable knowledge base to support their work with students and to raise the capacity of their departments and schools. Politics still play a role in many hiring decisions. A crucial consideration for educational leaders is whether or not they have the courage to swim upstream for the benefit of students. One of the most important decisions an educational leader makes is determining who will be on the front line with students. There is a significant cost to students when the best available educator, in terms of knowledge, teaching ability, relationship-building skills and professionalism is bypassed for the wrong reasons.

Knowledge is not static. We have all seen amazing changes wrought over the past several decades in many fields, including neuroscience and technology. Dr. Mack did not rely on her initial knowledge base. She remained current, growing her knowledge and learning about emerging areas of study. She was able to capitalize on many opportunities because of her need to know. There are many ways in which educational leaders can build the knowledge capacity of their departments and schools. Are new developments shared in discussions at meetings? Is information provided through newsletters, podcasts, websites, email, and other sources? Do the supervisory model and/or evaluation structure in the school encourage collaborations and dialogue groups for the express purpose of building knowledge capacity? In all of this, educational leaders can reflect on how they

are building their depth of knowledge and what type of opportunities they are providing for others. A most important consideration is whether this lifelong learning is facilitated in enjoyable ways. Even at her parties, Dr. Mack found fun ways to bring knowledge to the table.

Another aspect pertaining to depth of knowledge is what students are studying. Secondary and tertiary leaders may want to consider collaborating on program sequences that would build student depth of knowledge in a domain over the course of a secondary-tertiary program. Broad curriculums in courses with little depth and lack of a well-planned sequence of study do not support building deep knowledge in a domain. An articulated plan between secondary and tertiary education could provide a significant range of options for students to delve deeply into content with relevant, authentic work. This topic will be expanded upon in the section on *Working on the Work.*

Bloom's Taxonomy Revisited

Higher-order thinking skills are threaded throughout the data from Dr. Mack's life story and the literature on leadership and creativity. Dr. Mack excelled at moving beyond the knowledge, comprehension, and application levels. One of the six leader traits discerned by Kirkpatrick and Locke (1991/1995) was the cognitive ability required for the analysis and synthesis of large quantities of information. Dr. Mack consistently displayed such cognitive ability. She also exhibited the cognitive abilities at the top range of the newer version of Bloom's Taxonomy, evaluating and creating, exemplified by her novel bone density methodology. Her research endeavors and her work with students resided in Bloom's upper, more complex and abstract realm.

Secondary educational leaders, especially, have many competing pressures when it comes to providing leadership for the development of higher-order thinking skills. Learning endeavors that support the development of the higher range of skills require time and a different approach than a routine of lectures and note-taking. The same time pressure in preparing for standardized testing that may foster a breadth rather than depth approach to content can also foster reliance on activities yielding basic recall and perhaps comprehension. At both the secondary and tertiary levels, teacher-centered classrooms have a long history. Secondary and tertiary leaders may find it beneficial to use a clinical team model, visiting classrooms by department or building for the express purpose of getting a sense of the level of thinking involved in what students are actually doing as opposed to what we think we are asking them to do. Generative dialogues on the findings can lead to identification of any gaps between what is intended or desired to be happening and what is actually taking place. If STEM fields and the demands of the 21st century place a premium on applying, analyzing, evaluating, and creating and our students are not engaged in learning endeavors that stretch and grow these skills, the educational leader and his or her team can surface the issue, make it a priority, and work with others to formulate a plan to raise the level of expectation.

Divergence Value Modeling: Creativity, Nonconformance, Risk-taking, and Role Perception

Dr. Mack was a creative individual as seen through several creativity lenses. She was creative in her leadership endeavors to encourage and support students' interest in science and their academic and research success. She utilized her higher-order thinking skills and creativity to develop novel methodologies that advanced her fields. She

creatively approached issues such as forced retirement and found fitting solutions. In summary, she was astute in both identifying problems and solving them. Dr. Mack was nonconforming in her roles. She did not fit Dean Wendt's mold as a college professor, yet she was highly successful as an educator. She was not deterred by the pressure to conform to the nay-saying perspectives of others and stayed the course on what proved to be valid and valuable research paths. She most certainly did not conform to the stereotypical feminine role, exhibiting traits more reflective of masculine leadership. She encouraged and supported women and minorities in achieving to their potential irrespective of their gender or ethnicity. Dr. Mack's stellar achievements relate to her ability for and value of divergence. The issues surrounding divergence have many implications for secondary and tertiary educational leadership.

Divergence value modeling for creating the conditions conducive to attracting, educating, and retaining individuals in STEM disciplines is inherently a systemic issue. Diversity days, assemblies, and posters are not sufficient to permeate the atmosphere and operations of an educational institution. Every aspect of a student's experience contributes to his or her perception. Systemic considerations are compounded when students mediate the effects of experiences through their interpretations of events instead of the events themselves. Leadership in divergence value modeling involves every individual in an organization who contributes to the perceptions of students.

In meeting with a secondary science faculty one day, it struck me that there were no female and no minority department members. In modeling a value for divergence, it is important to consider the perceptions of students when their role models in STEM fields do not reflect the engagement of diverse individuals. Ensuring that students have diverse

role models who are enthusiastic about their fields and highly knowledgeable assists students in moving past role stereotypes when considering career options. Another consideration is the nature of relationships discussed previously in this chapter. Do all students feel safe and supported? Are issues dealt with promptly and fairly? Does the organization reflect respect and value for all individuals? In promoting positive, supportive relationships among students, does the educational leader expect the same in staff-to-staff and staff-to-student relationships? Students will be perceptive to all aspects of the atmosphere in an organization.

Educational leaders and their teams may find a fruitful path in examining and dialoging on the differentiated aspects of what takes place in the classroom. Kaufman (2009) addresses the issues of course restructuring in leadership education in pursuit of addressing the needs of a more diverse student clientele. Though Kaufman's context differs, the issue is relevant to today's secondary and tertiary clientele. In the exploration of systemic divergence value modeling, many classroom matters surface for consideration. Do students have appropriate choices and diverse pathways to achieve learning objectives? Are risk-takers supported in their novel approaches to solving problems? Are all students engaged in contributing to the work at hand? In all of the potential endeavors that have implications for educational leadership, are the leaders modeling for students and staff the same value for equity in participation, divergent pathways to accomplishing objectives, and openness to novel ideas to grow the capacity of the organization? Student perceptions will derive from the totality of their experiences in their learning organizations.

Expectations

Expectations for self and others were instrumental in Dr. Mack's life and success. While one could debate the desirability degree of her maternal expectations, Dr. Mack was influenced by and lived up to her mother's academic and work ethic expectations. Dr. Mack internalized these expectations, with successes leading to expectancy of further success. Her prolific output reflected high quality, substantial effort, and her proclivity for lifelong learning. Dr. Mack held these same high expectations for her students. She devoted extensive hours in helping students achieve, tutoring and stretching them as needed. Her staff members were subjected to these expectations as well- she wanted things done right and done right now. While students and staff sometimes experienced negative emotions in their efforts to meet these expectations, the quality of their work, their successes in research, teaching, and other careers, and their altered perceptions of their own capabilities indicate that her expectations were attainable and produced the desired outcomes.

When my son was in kindergarten, he typically brought home work that was illegible and of rather poor quality. However, every so often he would show up with a stellar product. Puzzled, I queried him on why his work varied so much. He had an immediate response. *"That's easy. Mr. R. was our teacher today. He has a saying- do it nice or do it twice."* His substitute teacher expected the work to be done in a quality manner, so that is what he did. In kindergarten, he was already adept at figuring out what level of expectations he had to meet. Fortunately, his mother's expectations and his intrinsic motivation mediated any future low classroom expectations.

The data from Dr. Mack's life story and the kindergarten story have tremendous implications for secondary and tertiary educational leaders. Human nature being what it is, many times individuals will perform or achieve to perceived expectation levels. If those levels are low, individuals miss the opportunity to develop higher expectations for themselves and the confidence that they can handle those expectations. The message that is received when leaders accept mediocre work from staff members and staff members accept mediocre work from students is that mediocre is acceptable and is the norm. Educational leaders, with a bedrock belief that all students and staff can achieve to high levels, can refute empty excuses and provide support while maintaining the focus on expectations. In looking at the data from two mathematics classes with similar student demographics, I wondered why over three times as many students in one class had attained proficiency versus the other class. Different staff perceptions of student capabilities and different expectations emerged. Expectations matter.

Expectations for students are also held by parents and the community. As previously discussed in Chapter II, many parents are aware of our nation's mediocre performance in mathematics and science, but are less aware of the need for skills in these areas in the jobs that will be available for their children. Many do not expect their students to pursue these fields by persevering in rigorous courses of study. Engaging parents and the larger community in endeavors to build their awareness and expectations for their children provides potential synergy with the efforts of the school.

Scaffolding for Attribute Development: Confidence, Perseverance, and Expectancy of Success

Vygotsky's ZPD has applicability for secondary and tertiary educational leaders in their efforts to facilitate development of attributes that support student success in STEM and other fields and in daily life. Many attributes develop over the course of time through successful participation in challenging, authentic experiences. Confidence, perseverance, and expectancy of success are intertwining factors in whether or not outcomes are successful.

Kanter (2004) proposes that confidence is the bridge connecting expectations and performance, investment and results. Confidence encompasses our positive expectations for favorable outcomes and influences our willingness to devote time, energy, and other resources to endeavors. Whether or not we invest those resources affects our ability to perform. Dr. Mack was a highly confident individual who expected positive outcomes. Her expectancy of success strongly influenced her willingness to invest her time, energy, financial resources, and reputation in pursuit of her objectives in research and her engagement and support of others in science, particularly women and minorities. Her confidence supported her drive to pursue research funding and also attracted the support of those with the money. She was confident her students and staff would be successful in their research and devoted her resources to them. While students and staff may have been aggravated at Dr. Mack's desire for perfection, their survival of the process and successful outcomes bred confidence.

As Kanter (2004) indicates, success and failure are not episodes, they are trajectories. While each school year appears to be a new event, it is formed by what has

occurred in prior years. What have been the experiences of each member of an organization? Does history suggest an upward trajectory or otherwise? What type of demeanor and body language is apparent in the organization? How welcoming is the environment? Is there a sense of solidarity and purpose? From facial expressions to symbolic gestures, to the level of pride in one's organization, to the sense of teamwork, and the meaningfulness of the work, do the organization and its members reflect the confidence to support a successful trajectory?

Educational leaders at the secondary and tertiary levels are positioned to derail negative self-fulfilling prophecies. In their work with staff members and interactions with students, they can portray confidence that delivers the message that success is attainable. They can identify and provide necessary supports to help others attain success leading to confidence. Educational leaders, in remaining open to the independent opinions of their staff members and students, are demonstrating confidence in the abilities of others.

In the classroom, confidence in students' abilities combined with carefully structured supports that are gradually withdrawn when no longer needed provide a foundation for students to gain confidence in their abilities. Confidence in eventual success can facilitate student perseverance in challenging work. High levels of performance emerge from investment of resources, which is affected by confidence. Confidence gained through successful outcomes in relevant and challenging work offers the potential to support student perseverance in the cognitive and affective demands of STEM fields.

Facilitating Development of Communication and Interpersonal Skills

Dr. Mack exhibited legendary communication and interpersonal skills. She was in high demand as a presenter, entertaining and effective in communicating her message. She had the ability to engage in conversation with individuals from all walks of life. Individuals who were initially put off by her appearance and lack of attention to making herself attractive quickly formed new opinions when she began to speak. Her persuasiveness attracted jobs, funding, students, and the right people needed to get the work accomplished. Dr. Mack's involvement with state and national organizations for the support of students and her collaborations with researchers and students from other institutions grew out of her communication and interpersonal skills. The development of her chemistry program of study at PSU and the dissemination of her research for the benefit of her domains, fields, and the general public were dependent upon her written communication skills. The ability to communicate in whatever style to any audience was a critical aspect of her success.

Verbal skill development. One downside to the accountability era is the unintended consequence related to a reduced focus on what is not measured. While there are standards for speaking and listening, assessments involved in determining AYP (for instance, Pennsylvania's PSSA) do not measure students' abilities in areas that are important for their future success. Whether it is collaborating with others across the globe through some type of video conferencing, pitching ideas to one's boss, or landing a job in the first place, the ability to effectively communicate ideas to others is a crucial factor in an individual's success. As the world seemingly shrinks due to the advancement of

technology, receptive language skills pertaining to diverse communication styles and formats also become increasingly important.

Educational leaders have opportunities to grow their communication skills and model the usage of varied technological formats. They can also set the expectation that teachers will vary their communication formats. Educators can work together to determine how and when students will learn various communication skills and apply them. Educators can work together to maximize authentic opportunities for students to present their work to varied audiences. Opportunities for productive debate and development of persuasive skills can be embedded in daily work. Direct teaching of skills, embedded practice, and presenting of authentic, meaningful work can assist students in gaining confidence in their communication abilities.

Technical writing skill development. Secondary and tertiary educational leaders are similarly challenged when faced with the development of students' writing skills. Modern forms of communication, including instant messaging, blogging, and texting encourage a very informal and abbreviated style of writing. This is the antithesis of a highly organized, technically adept and focused grant proposal, journal article, technical manual, or research report. This may be another instance where collaboration among secondary and tertiary educators and workforce representatives can assist in articulating what is needed and when and how to embed the skills in which particular authentic student endeavors. Secondary and tertiary educational leaders could take a leadership role in this endeavor by reaching out to establish connections with each other and other organizations.

Congruence between words and actions. The leadership literature is replete with caveats regarding the critical issue of congruence between words and actions to build and maintain trust. In many ways, Dr. Mack exemplified this congruence. She followed through on her promises to students to assist them with their work, spending considerable time on this. While her students and staff may not have always agreed with her, her actions and words were aligned. As Dr. Pond would have found out, had he survived, and as Dr. Guinn discovered, Dr. Mack delivered on her promises. Persuasive, articulate, and charismatic, Dr. Mack's communicative versatility was not hollow. As noted in Chapter IV, there were a few times when individuals felt that trust was broken, leading to permanent separation and hard feelings.

For secondary and tertiary educational leaders, congruence between their words and actions facilitates trust with staff members, students, and those in external contexts. A mismatch here causes uncertainty and interferes with the trust necessary to build organizational capacity. Ongoing reflection on one's congruence can be very helpful. When teachers exhibit a mismatch between their words and actions, student trust is affected. Students may be less likely to engage in classroom endeavors with full commitment when trust is not established with teachers. Exhibiting congruence and expecting congruence facilitates a trusting environment supportive of building personal and organizational capacity.

Collaboration and networking. Collaboration and networking have been discussed throughout this study. One can visualize Dr. Mack immersed in a neural network with massive amounts of information flowing through synapses between neurons. Dr. Mack was a constructor of networks. It is evident that others were involved

in every facet of her successful endeavors. Her ability to interest others to invest their resources in support of her objectives was a critical factor in her achievements. Dr. Mack involved everyone- her parents, her husband, her students, her colleagues, other people's students, government agencies, industry, her office staff, and her gardener- in pursuit of her objectives. Each endeavor, including writing her chemistry textbook, producing *The Chemistry Leaflet*, completing her dissertation, building her densitometer, her 25th wedding anniversary celebration, and her NASA projects, involved substantial investments of time, energy, resources, and talents of others. Dr. Mack supported others and was highly supported by others. Grand scale achievement does not occur in isolation.

Educational leaders in secondary and tertiary settings have endless opportunities to model collaboration and networking, beginning with their work with other members of their organization and in their outreach beyond the organization. Leaders can involve students in councils and committees that are substantive in nature to support development of collaborative skills. Educators can provide collaborative contexts within and beyond the classroom walls to provide ongoing, authentic contexts for students to build their collaborative capacities. Educators, counselors, administrators, and others can assist students in the development of negotiation, mediation, and conflict resolution skills. Contexts can be established in which success can be attained only through the combined efforts of group members.

Pursuing education and a career in STEM fields can present a daunting challenge for students. Collaborative and networking skills have the side benefit of providing students with the abilities to seek out the support and insight of others. With this support, the journey may not seem as overwhelming and isolating.

Working on the Work

Schlecty's (2002; Sparks, 1998) *Working on the Work* framework, examined in Chapter II of this study, suggests that student engagement and achievement is more likely to improve if we shift the focus from improving teacher performance to improving the quality of work teachers give to students. Since the focus of school should be on students' intellectual activity, and students will not learn from work they do not do, he advocates for good work. Good school work is compelling enough that students will persist in the face of difficulty and derive satisfaction from completing it. Students will then learn things valued by their parents, community, and society in general. Gardner, Csikszentmihalyi, and Damon (2001) also focused on good work. Their definition of good work was that which combined excellent quality with social responsibility during a time of constant change.

Dr. Mack's life story portrays both definitions of good work. In her work with students, Dr. Mack suggested productive avenues for study and assisted students in extending their studies into meaningful realms. The work was compelling and produced results that benefitted others. Dr. Mack was highly effective in combining excellent work with social responsibility in changing contexts. She utilized the results of her studies to advocate for better nutrition for individuals in less fortunate circumstances. She was persistent in her pursuit of industry standards in her role as consumer advocate. Dr. Mack supported women and minorities in pursuit of their education and careers. She carried out good work, her students carried out good work, and her employees carried out good work.

Aspects of good work have been touched upon in the previous segments of this chapter. Educational leaders may find it highly beneficial to structure opportunities for staff members to collaborate on the examination of student work. Focusing attention on what students are doing ameliorates the perception that the teacher needs fixing. A focus on the quality of work assigned to students can reduce resistance in the efforts to build organizational capacity. The levels of thinking required by students can be evaluated as part of the dialogue on the quality of the work. While working on the quality of work, educators can consider when and how student work can contribute to the building of social responsibility. Student work that contributes to the organization, the community, and the larger world supports the development of social responsibility.

Self-Management: A Healthy Balance

The York Sunday News on March 29, 2009 caught my eye with a mention of the Victory Gardens that were promoted during World War II, partly to reduce the demand on the food supply (p. B1). This mention brought to mind the Victory Garden work of Pauline and Warren Mack and the connections to our current economic crises. It would be an oversight not to address the implications of Dr. Mack's nutrition research for educational leaders, organization members, and students. Dr. Mack devoted a significant portion of her life to examining the effects of nutritional variables on human well-being. Her concern for the effects of nutrition during pregnancy on infants, her advocacy for the ideal school lunch to fill in the nutritional deficiencies of children, and her investigations of the poor nutrition of teenagers and the effects on their energy levels spoke to the need for making sure everyone in every stage of life had their nutritional needs met.

We live in difficult economic times. By choice or by need, many individuals are not consuming adequate nutrients to fuel them now and to facilitate their good health in the future. For students, and for that matter, staff members, to succeed in good work, they need to have the necessary fuel. In establishing the contexts for supporting the engagement, education, and retention of students in STEM fields, educational leaders can also model social responsibility by ensuring that those of whom they expect much from are not disadvantaged by hunger or extremely poor nutrition.

Congruence: The Right Seat on the Right Bus

Perhaps the most significant implication to take from Dr. Mack's life story is the issue of congruence. Dr. Mack had situational mastery. She had the right skills and attributes, the depth of knowledge, the creativity, the drive, the communication skills, and others, to be highly congruent with her dual roles as teacher and researcher. She was positioned to take the right seat on the right bus, which happened to be a driver's seat, because she prepared for and was prepared by her experiences and education. All of the above implications for secondary and tertiary educational leaders coalesce in the desire to help students and teachers in being prepared to determine which seat is right for them and to be able to claim it. The ultimate goal is to have the STEM bus be an available option for any student.

References

Ackerman, P. L., & Lohman, D. F. (2006). Individual differences in cognitive functions. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 139-161). Mahwah, NJ: Lawrence Erlbaum Associates.

Amabile, T. M. (1993). What does a theory of creativity require? *Psychological Inquiry, 4*(2), 179-237. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=1047-840X%281993%294%3A3%3C179%3AWDATOC%3E2.0.CO%3B2-O

Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal, 39*(5), 1154-1184. Retrieved October 21, 2007, from http://links.jstor.org/sici?sici=0001-4273%28199610%2939%3A5%3C1154%3AATWEFC%3E2.0.CO%3B2-W

American Council on Education. (2006). *College enrollment gender gap widens for white and Hispanic students, but race and income disparities still most significant new ACE report finds*. Retrieved October 24, 2007, from http://www.acenet.edu/AM/Template.cfm?Section=HENA&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=17251

American Psychological Association Task Force on Intelligence. (1995). *Stalking the wild taboo- intelligence: Knowns and unknowns* (Report of a Task Force established by the Board of Scientific Affairs of the American Psychological Association). Retrieved October 24, 2007, from http://www.lrainc.com/swtaboo/taboos/apa_01.html

Anderson, M. (1995). Ahead of the wave: Valuing gender perspective in learning cultures. In S. Chawla & J. Renesch (Eds.), *Learning organizations: Developing cultures for tomorrow's workplace* (pp. 57-68). Portland, OR: Productivity Press.

Ash, R., & Persall, M. (n.d.). *The principal as chief learning officer: The new work of formative leadership*. Retrieved November 13, 2007, from http://www.middleweb.com/ash.html

Baldi, S., Jin, Y., Skemer, M., Green, P. J., & Herget, D. (2007). *Highlights from PISA 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context* (NCES 2008-016). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved December 4, 2007, from http://nces.ed.gov/pubs2008/2008016.pdf

Barbacane, R. (2007, November 13). *Improving student achievement… Insight and advice from a fellow practitioner*. Electronic correspondence sent by National Association of Elementary School Principals.

Barnhill, R. E. (2004, July). Update on national developments in graduate education. *Riding the Momentum of Research: Leadership Challenges in Public Research Universities, 108*. Retrieved October 29, 2007, from http://merrill.ku.edu/publications/2004whitepaper/barnhill.html

Belkin, L. (2003, October 26). The opt-out revolution. *The New York Times Magazine*. Retrieved November 20, 2007, from http://www.nytimes.com/2003/10/26/magazine/26WOMEN.html?ex=1382500800&en=02f8d75eb63908e0&ei=5007&partner=USERLAND

Bereiter, C., & Scardamalia, M. (2006). Education for the knowledge age: Design-centered models of teaching and instruction. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 695-713). Mahwah, NJ: Lawrence Erlbaum Associates.

Biddle, B. J. (1986). Recent developments in role theory. *Annual Review of Sociology, 12*, 67-92. Retrieved December 9, 2007, from http://links.jstor.org/sici?sici=0360-0572%281986%2912%3C67%3ARDIRT%3E2.0.CO%3B2-3

Biemiller, L. (2008). A cottage that belongs to the ages. *The Chronicle of Higher Education*, *54*(20), p. A8. Retrieved February 4, 2008, from http://chronicle.com/weekly/v54/i20/20a00801.htm?utm_source=at&utm_medium=en

Bowen, E. R. (n.d.). *Student engagement and its relation to quality work design: A review of the literature.* Retrieved November 5, 2007, from http://chiron.valdosta.edu/are/ebowenLitReview.pdf

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. San Francisco: Jossey-Bass.

Bransford, J., Stevens, R., Schwartz, D., Meltzoff, A., Pea, R., Roschelle, J., et al. (2006). Learning theories and education: Toward a decade of synergy. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 209-244). Mahwah, NJ: Lawrence Erlbaum Associates.

Braxton, J. M., Luckey, W., & Helland, P. (2002). *Institutionalizing a broader view of scholarship through Boyer's four domains*. Washington, DC: ERIC Clearinghouse on Higher Education. Retrieved November 25, 2007, from http://www.ericdigests.org/2003-3/four.htm (ERIC Document Reproduction Service No. ED469447)

Breslow, J. M. (2007, November 8). A glance at the November 8 issue of *The New England Journal of Medicine*: Starting a family in medical school. *The Chronicle of Higher Education*. Retrieved November 8, 2007, from http://chronicle.com/daily/2007/11/631j.htm

Building Engineering & Science Talent. (2004, February). *A bridge for all: Higher education design principles to broaden participation in science, technology, engineering, and mathematics*. Retrieved October 29, 2007, from http://www.cahsee.org/news/BEST_High_Ed_Rep_48pg_02_25.pdf

Burns, J. M. (1978). Transactional and transforming leadership. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 100-101). New York: The Free Press.

Business-Higher Education Forum. (2006). *Securing America's leadership in science, technology, engineering, & mathematics*. Retrieved October 29, 2007, from http://www.bhef.com/solutions/STEMBrochure2006.pdf

Cahan, S., & Yael, G. (1995, April). Cognitive gender differences among Israeli children. *Sex Roles: A Journal of Research*. Retrieved November 27, 2007, from http://findarticles.com/p/articles/mi_m2294/is_n7-8_v32/ai_17482719/print

Chase, S. E. (2005). Narrative inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 651-679). Thousand Oaks, CA: Sage Publications.

Chase, S. E. (2008). Narrative inquiry: Multiple lenses, approaches, voices. In N. K. Denzin & Y. S. Lincoln (Eds.), *Collecting and interpreting qualitative materials* (3rd ed., pp. 57-94). Thousand Oaks, CA: Sage Publications.

Chemers, M. M. (1984). Contemporary leadership theory. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 83-99). New York: The Free Press.

Chickering, A. W., & Gamson, Z. F. (1987, March). Seven principles for good practice in undergraduate education (Reprinted from *The American Association for Higher Education Bulletin*). Retrieved November 22, 2007, from http://honolulu.hawaii.edu/intranet/committees/FacDevCom/guidebk/teachtip/7princip.htm

Christianson, G. E. (1994). *Writing lives is the devil! Essays of a biographer at work* [Summary]. Retrieved February 12, 2008, from http://www.biggerbooks.com/bk_detail.aspx?isbn=9780208023827

Clark, P. M., & Mirels, H. L. (1970). Fluency as a pervasive element in the measurement of creativity. *Journal of Educational Measurement, 7*(2), 83-86. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0022-0655%28197022%297%3A2%3C83%3AFAAPEI%3E2.0.CO%3B2-T

Collins, J. (2001). *Good to great: Why some companies make the leap. . . and others don't*. New York: Harper Business.

Colom, R., Quiroga, M. A., & Juan-Espinosa, M. (1999). Are cognitive sex differences disappearing? *Personality and Individual Differences*, *27*(6), 1189-1195. [Abstract] Retrieved November 27, 2007, from http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V9F-3X52WPF-H&_user=10&_coverDate=12%2F31%2F1999&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=5ed3cc050f6eb4f5cd4d475f4ae5f4bc

Colwell, R. R. (2001, April 09). *From glass ceiling to crystal ball: A vision of women in science*. NSF Director Rita R. Colwell's remarks to Radcliffe Institute for Advanced Study. Retrieved October 17, 2007, from http://www.nsf.gov/news/speeches/colwell/rc010409radclif.htm

Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2006). *Beyond bias and barriers: Fulfilling the potential of women in academic science and engineering* [Executive Summary]. Retrieved October 25, 2007, from http://www.nap.edu/catalog.php?record_id=11741

Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2006, September 18). Broad national effort urgently needed to maximize potential of women scientists and engineers in academia. *The National Academies NEWS*. Retrieved October 25, 2007, from http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11741

Council of Chief State School Officers. (1996). *Interstate Leadership School Licensure Consortium standards for school leaders.* Washington, DC: Author. Retrieved November 24, 2007, from http://www.ccsso.org/content/pdfs/isllcstd.pdf

Couto, R. A. (1993). The transformation of transforming leadership. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 102-107). New York: The Free Press.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage Publications.

Csikszentmihalyi, M. (1993). Does overinclusiveness equal creativity? *Psychological Inquiry, 4*(3), 188-189. Retrieved October 23, 2007, from http://links.jstor.org/sici=1047-840X%281993%294%3A3%3C188%3ADOEC%3E2.0.CO%3B2-6

Daniel, C. L. (2005). *The relationship between levels of moral reason and transformational leadership behaviors of West Virginia public school administrators* (Doctoral dissertation, Marshall University Graduate College, 2005).

Denzin, N. K., & Lincoln, Y. S. (Eds.). (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 1-32). Thousand Oaks, CA: Sage Publications.

Diamond, R. M. (2006). *Tenure and promotion: The next iteration*. Retrieved November 26, 2007, from http://www.thenationalacademy.org/readings/tenpromo.html

Duderstadt, J. J. (2008). *Engineering for a changing world: A roadmap to the future of engineering practice, research, and education*. Ann Arbor, MI: The University of Michigan Millennium Project.

DuFour, R. (2003, May). Building a professional learning community: For system leaders, it means allowing autonomy within defined parameters. *The School Administrator*. Retrieved October 10, 2007, from http://www.aasa.org/publications/saarticledetail.cfm?ItemNumber=2909&snItemNumber=&tnItemNumber=

Eccles, J. S. (1986). Gender-roles and women's achievement. *Educational Researcher, 15*(6), 15-19. Retrieved October 21, 2007, from http://links.jstor.org/sici?sici=0013-189X%28198606%2F07%2915%3A6%3C15%3AGAWA%3E2.0.CO%3B2-E

Emerson, R. W. (1876). *The complete works of Ralph Waldo Emerson- Volume VIII-Letters and social aims*. Retrieved November 22, 2007, from http://www.rwe.org/?option=com_content&task=view&id=47&Itemid=42

Eysenck, H. J. (1995). *Genius: The natural history of creativity (Problems in the behavioural sciences).*Cambridge, UK: Cambridge University Press.

Farooq, U. (2004). Eureka! Past, present, and future of creativity research in HCI. *The ACM Student Magazine*. Retrieved October 22, 2007, from http://www.acm.org/crossroads/xrds12-2/eureka.html

Feingold, A. (1988). Cognitive gender differences are disappearing. *American Psychologist, 43*, 95-103.

Feingold, A. (1993). Cognitive gender differences: A developmental perspective. *Sex Roles, 29*(1-2), 91-112. [Abstract] Retrieved November 27, 2007, from http://www.springerlink.com/content/v510096201210715/

Finson, K. D. (2002). *Drawing a scientist: What we do and do not know after fifty years of drawings*. Retrieved October 28, 2007, from http://findarticles.com/p/articles/mi_qa3667/is_200211/ai_n9160846

Fischer, K. (2007). 'Flat world' lessons for real-world students. *The Chronicle of Higher Education*, *54*(10), p. A35. Retrieved November 2, 2007, from http://chronicle.com/weekly/v54/i10/10a03502.htm

Ford, J. D. (n.d.). *What is creativity?* Retrieved November 01, 2007, from http://newmusicclassics.com/resume_folder/historicism_creativity.html

Fosnot, C. T. (2005a). Epilogue- Constructivism revisited: Implications and reflections. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (2nd ed., pp. 276-291). New York: Teachers College Press.

Fosnot, C. T. (2005b). Preface. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (2nd ed., pp. ix-xii). New York: Teachers College Press.

Fosnot, C. T., & Perry, R. S. (2005). Constructivism: A psychological theory of learning. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (2nd ed., pp. 8-38). New York: Teachers College Press.

Friedman, T. L. (2006). *The world is flat: A brief history of the twenty-first century*. New York: Farrar, Straus and Giroux.

Fung, Y. Y. H. (2002). A comparative study of primary and secondary school students' images of scientists. *Research in Science & Technological Education, 20*(2), 199-213. Retrieved November 27, 2007, from http://navigator-iup.passhe.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=trh&AN=8633703&site=ehost-live

Gardner, H. (1993). *Creating minds: An anatomy of creativity seen through the lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi*. New York: Basic Books.

Gardner, H. (1997). *Extraordinary minds: Portraits of exceptional individuals and an examination of our extraordinariness*. New York: Basic Books.

Gardner, H. (2003, April). *Multiple intelligences after twenty years.* Paper presented at the American Educational Research Association, Chicago, IL. Retrieved October 31, 2007, from http://www.pz.harvard.edu/PIs/HG_MI_after_20_years.pdf

Gardner, H., Csikszentmihalyi, M., & Damon, W. (2001). *Good work: When excellence and ethics meet*. New York: Basic Books.

Goldberg, M. F. (2001). Leadership in education: Five commonalities. *Phi Delta Kappan, 82*(10), 757-761. Retrieved November 13, 2007, from http://www.pdkintl.org/kappan/k0106gol.htm

Goleman, D., Boyatzis, R., & McKee, A. (2002). *Primal leadership*: *Realizing the power of emotional intelligence*. Boston: Harvard Business School Press.

Gorny, E. (2007). *Ten-year rule*. Retrieved December 2, 2007, from http://creativity.netslova.ru/Ten-year_rule.html

Graff, F. (2001, December 1). Breakthrough thinking and the eureka effect: An interview with Professor David Perkins. *HGSE News*. Retrieved October 31, 2007, from http://www.gse.harvard.edu/news/features/perkins12012001.html

Gravois, J. (2007). Alleging gender bias, 8 professors sue Penn State. *The Chronicle of Higher Education, 53*(36), p. A23. Retrieved November 2, 2007, from http://chronicle.com/weekly/v53/i36/36a02302.htm

Greenfield, P. M., Trumbull, E., Keller, H., Rothstein-Fisch, C., Suzuki, L. K., & Quiroz, B. (2006). Cultural conceptions of learning and development. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 675-692). Mahwah, NJ: Lawrence Erlbaum Associates.

Guba, E. G., & Lincoln, Y. S. (2005). Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 191-215). Thousand Oaks, CA: Sage Publications.

Halpern, D. F. (1989). The disappearance of cognitive gender differences: What you see depends on where you look. *American Psychologist, 44*, 1156-1158.

Halpern, D. F. (1997, October). Sex differences in intelligence: Implications for education. *American Psychologist, 52*(10), 1091-1102. Retrieved October 21, 2007, from PsycARTICLES database.

Halpern, D. F. (2006). Assessing gender gaps in learning and academic achievement. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 635-653). Mahwah, NJ: Lawrence Erlbaum Associates.

Halpern, D. F., Wai, J., & Saw, A. (2005). A psychobiosocial model: Why females are sometimes greater than and sometimes less than males in math achievement. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 48-72). New York: Cambridge University Press. Abstract retrieved October 21, 2007, from PsycINFO database.

Haring-Smith, T. (2006). *Creativity research review*. Retrieved October 22, 2007, from http://findarticles.com/p/articles/mi_qa4115/is_200604/ai_n17181524

Hartle, R. T. (2007). A collection of research reporting, theoretical analysis, and practical applications in science education: Examining qualitative research methods, action research, educator-researcher partnerships, and constructivist learning theory. D.A. dissertation, Idaho State University. Retrieved October 28, 2007, from Dissertations & Theses: Full Text database. (Publication No. AAT 3266415)

Heifetz, R. A. (1994). *Leadership without easy answers*. Cambridge: The Belknap Press of Harvard University Press.

Heilman, M. E. (1997). Sex discrimination and the affirmative action remedy: The role of sex stereotypes. *Journal of Business Ethics*, *16* (9), 877-889. Retrieved November 30, 2007, from http://vnweb.hwwilsonweb.com/hww/jumpstart.jhtml?recid=0bc05f7a67b1790e8eaf21359a46e922024a3c8841fc48e64f8b1a332fdefbd2f394af86f0c2edbd&fmt=P

Hersey, P., & Blanchard, K. H. (1979). Behavioral theories of leadership. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 144-148). New York: The Free Press.

Holland, H. (n.d.). *A collegial conversation- Talking about instruction helps teachers find new ways to engage students*. Retrieved November 5, 2007, from http://www.schlechtycenter.org/pdfs/collegial.pdf

Hrabowski III, F. A. (2007, October). *UMBC as a national model: The university as mentor.* Testimony before the Subcommittee on Research and Science Education, House Committee on Science & Technology, Washington, DC. Retrieved October 29, 2007, from http://www.umbc.edu/aboutumbc/president/testimony_10-17-07.pdf

Huber, R. A., & Burton, G. M. (1995, November). What do students think scientists look like? *School Science and Mathematics*. Retrieved December 1, 2007, from http://findarticles.com/p/articles/mi_qa3667/is_199511/ai_n8727650

Hubka, T. (2006, May 04). Thoughts on shattering science's glass ceiling. Female students are a majority in science classrooms, but male faculty members outnumber their female counterparts. *Oregon Daily Emerald*. Retrieved October 17, 2007, from http://www.dailyemerald.com/home/index.cfm?event=displayArticlePrinterFriendly&uStory_id=2826a068-4a1e-434f-93bf-2cb6a6864225

Hutchings, P., Babb, M., & Bjork, C. (2002). *The scholarship of teaching and learning in higher education: An annotated bibliography*. Retrieved November 27, 2008, from http://www.ipfw.edu/celt/learning/documents/solt_carnegie.pdf

Institute for Educational Leadership. (2000, October). *Leadership for student learning: Reinventing the principalship* (School Leadership for the 21st Century Initiative: A Report of the Task Force on the Principalship). Retrieved November 13, 2007, from http://www.iel.org/programs/21st/reports/principal.pdf

Institute for Educational Leadership. (2007, December). *2007 leadership forum: Making the global connections*. Conference booklet presented at the meeting of the Education Policy Fellowship Program, Atlanta, GA.

International Society for Technology in Education. (2002). *Technology standards for school administrators: Framework, standards, and performance indicators*. Retrieved November 24, 2007, from http://cnets.iste.org/administrators/pdf/NETSA_Standards.pdf

ISTE, P21, & SETDA. (2007). *Maximizing the impact: The pivotal role of technology in a 21st century education system*. Retrieved November 30, 2007, from http://www.setda.org/web/guest/maximizingimpactreport

Jackson, S. A. (2007, February). *Science and leadership: The imperative*. Paper presented at the Gustav Pollack Lecture, John F. Kennedy School of Government, Harvard University, Cambridge, MA. Retrieved October 29, 2007, from http://www.rpiscrews.us/homepage/quietcrisis/ps022207-harvardgustavpollack.html

Jacobson, N., Gewurtz, R., & Haydon, E. (2007, September). Ethical review of interpretive research: Problems and solutions. *IRB: Ethics & Human Research*, *29*(5), 1-8. Retrieved January 31, 2008, from Academic Search Complete database.

Jamieson, J. P., & Harkins, S. G. (2007). Mere effort and stereotype threat performance effects. *Journal of Personality and Social Psychology, 93*(4), 544-564.

Johnson, D. (2005, May). What does a tech-savvy administrator look like? *The School Administrator*. Retrieved November 13, 2007, from http://www.aasa.org/publications/saarticledetail.cfm?ItemNumber=2524

Kadlec, A., Friedman, W., & Ott, A. (2007). *Important, but not for me: Parents and students in Kansas and Missouri talk about math, science and technology education*. New York: Public Agenda. Retrieved December 5, 2007, from http://www.publicagenda.org/importantbutnotforme/pdfs/important_but_not_for_me.pdf

Kane, M., & Trochim, W. M. K. (2007). *Concept mapping for planning and evaluation*. Thousand Oaks, CA: Sage Publications.

Kanter, R. M. (2004). *Confidence: How winning streaks & losing streaks begin & end.* New York: Crown Business.

Kaufman, C. C. (2009, Winter). An innovative approach to course restructuring in leadership education. *Journal of Leadership Studies*, *2*(4), 62-65.

Kearsley, G. (2007). Social development theory (L. Vygotsky). *Explorations in learning & instruction: The theory into practice database*. Retrieved November 7, 2007, from http://tip.psychology.org/vygotsky.html

Kerber, L. K. (2005, March 18). We must make the academic workplace more humane and equitable. *The Chronicle of Higher Education*. Retrieved November 2, 2007, from http://chronicle.com/weekly/v51/i28/28b00601.htm

King, A., & Chamberlayne, P. (1996). Comparing the informal sphere: Public and private relations of welfare in East and West Germany. *Sociology, 30*(4), 741-761. Retrieved February 7, 2008, from http://soc.sagepub.com/cgi/content/abstract/30/4/741

Kirkpatrick, S. A., & Locke, E. A. (1991). Leadership: Do traits matter? In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 133-143). New York: The Free Press.

Knight, R. (2007, July 5). Women crack academia's glass ceiling in the US. *Financial Times* (London Edition, World News), p. 10. Retrieved October 20, 2007, from the LexisNexis database.

Kristinsdóttir, S. (2001). *Lev Vygotsky*. Retrieved November 7, 2007, from http://starfsfolk.khi.is/solrunb/vygotsky.htm

LaChapelle, J. R. (1983). Creativity research: Its sociological and educational limitations. *Studies in Art Education*, *24*(2), 131-139. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0039-3541%281983%2924%3A2%3C131%3ACRISAE%3E2.0.CO%3B2-R

Lashway, L. (2002, Spring). Rethinking the principalship. *Research Roundup*, *18*(3). University of Oregon: Clearinghouse on Educational Policy and Management. Retrieved November 13, 2007, from http://eric.uoregon.edu/publications/roundup/Spring_2002.html

Leadership Alliance Presidential Forum. (2005, April). *Summary statement: Panel on preparing undergraduate scholars for doctoral training*. Summary statement from the meeting of the Leadership Alliance Presidential Forum Panel, Washington, DC. Retrieved October 29, 2007, from http://www.theleadershipalliance.org/matriarch/documents/PreparingUndergraduateScholars.pdf

Leithwood, K. A., & Riehl, C. (2003, March). *What do we already know about successful school leadership?* Paper prepared for the AERA Division A Task Force on Developing Research in Educational Leadership. Retrieved November 24, 2007, from http://www.cepa.gse.rutgers.edu/What%20We%20Know%20_long_%202003.pdf

Levey, J., & Levey, M. (2000, January/February). Reflections for leaders: Corporate culture, organizational health, and human potential. *The EAPA Exchange*. Retrieved November 11, 2006, from http://www.wisdomatwork.com/BUSINESS/center/EAPA.html

Lewin, T. (2004, January 15). Despite gain in degrees, women lag in tenure in 2 main fields. *The New York Times*. Retrieved October 17, 2007, from nytimes.com

Liontos, L. B. (1992). *Transformational leadership*. Eugene, OR: ERIC Clearinghouse on Educational Management. (ERIC Document Reproduction Service No. ED347636) Retrieved November 16, 2007, from http://www.vtaide.com/png/ERIC/Transformational-Leadership.htm

Loveless, T. (2007). *The 2007 Brown Center report on American education: How well are American students learning? II*(2). Retrieved December 20, 2007, from http://www.brookings.edu/reports/2007/1211_education_loveless.aspx

Mark, N. K. (2008, February 3). Unbroken spirit: 5-year-old doesn't let rare disorder get in her way. *Centre Daily Times*. Retrieved February 5, 2008, from http://www.centredaily.com

Martin, A. (2007). *Everyday leadership* (A CCL Research White Paper). Center for Creative Leadership. Retrieved November 20, 2007, from http://www.ccl.org/leadership/pdf/research/EverydayLeadership.pdf

Masters, M. S., & Sanders, B. (1993). Is the gender difference in mental rotation disappearing? *Behavior Genetics*, *23*(4), 337-341. [Abstract] Retrieved November 27, 2007, from http://www.springerlink.com/content/p128326282275112/

McGregor, D., & Gunter, B. (2006). Invigorating pedagogic change. Suggestions from findings of the development of secondary science teachers' practice and cognizance of the learning process. *European Journal of Teacher Education*, *29*(1), 23-48. Retrieved September 12, 2007, from Academic Search Premier database.

Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students: A pilot study. *Science*, *126*(3270), 384-390. Retrieved December 1, 2007, from http://links.jstor.org/sici?sici=0036-8075%2819570830%293%3A126%3A3270%3C384%3AIOTSAH%3E2.0.CO%3B2-Z

Moore, R. (1966). The relationship of intelligence to creativity. *Journal of Research in Music Education, 14*(4), 243-253. Retrieved October 24, 2007, from http://links.jstor.org/sici?sici=0022-4294%28196624%2914%3A4%3C243%3ATROITC%3E2.0.CO%3B2-%23

Moran, S. (2008, in press). Creativity: A systems perspective. In T. Richards, M. Runco, & S. Moger (Eds.), *The Routledge companion to creativity*. London: Routledge.

Moran, S., & John-Steiner, V. (2003). Creativity in the making: Vygotsky's contribution to the dialectic of creativity and development. In K. Sawyer et al., *Creativity and development* (pp. 61-90). New York: Oxford University Press.

Moran, S., & John-Steiner, V. (2004). How collaboration in creative work impacts identity and motivation. In D. Miell & K. Littleton (Eds.), *Collaborative creativity: Contemporary perspectives* (pp. 11-25). London: Free Association Books.

Moran-Ellis, J., Alexander, V., Cronin, A., Dickinson, M., Fielding, J., Sleney, J., et al. (2006, February). Triangulation and integration: Processes, claims and implications. *Qualitative Research, 6*(1), 45-59. Retrieved January 31, 2008, from Academic Search Complete database.

Morrison, A. M., & Von Glinow, M. A. (1990). Women and minorities in management. In J. T. Wren (Ed.) (1995), *The leader's companion: Insight on leadership through the ages* (pp. 168-181). New York: The Free Press.

Moss Jr., J., & Jensrud, Q. (1995). Gender, leadership, and vocational education. *Journal of Industrial Teacher Education, 33*(1). Retrieved November 7, 2007, from http://scholar.lib.vt.edu/ejournals/JITE/v33n1/moss.html

National Center on Education and the Economy. (2007). *Tough choices or tough times: The report of the new commission on the skills of the American workforce executive summary*. Retrieved December 22, 2007, from http://www.skillscommission.org/executive.htm

National Research Council. (2008). *NASA's elementary and secondary education program: Review and critique*. Washington, DC: The National Academies Press.

National Science Teachers Association. (2007). Science, math not a priority, say parents, students. *NSTA Reports*, *19*(3), 29.

New Media Consortium. (2007, January). *Four to five years: New scholarship*. *The new scholarship and emerging forms of publication*. Retrieved November 25, 2007, from http://www.nmc.org/horizonproject/2007/new-scholarship

O'Donnell, A. M. (2006). The role of peers and group learning. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 781-802). Mahwah, NJ: Lawrence Erlbaum Associates.

Olson, R., Seftor, N., Silva, T., Myers, D., DesRoches, D., & Young, J. (2007). *Upward bound math-science: Program description and interim impact estimates*. Washington, DC: U.S. Department of Education Office of Planning, Evaluation and Policy Development.

O'Meara, K. A. (2005). Encouraging multiple forms of scholarship in faculty reward systems: Does it make a difference? [Abstract] *Research in Higher Education*, *46*(5), 479-510. Retrieved November 25, 2007, from http://www.springerlink.com/content/t5545434g8357433/

Osellame, J. (2006, September 25). At colleges, glass ceiling persists. *The Daily Princetonian*. Retrieved October 17, 2007, from http://www.dailyprincetonian.com/archives/2006/09/25/news/15915.shtml?type=printable

Pariser, D. (1993). Review of "The nature of creativity: Contemporary psychological perspectives," Robert. J. Sternberg, ed. *Leonardo, 26*(2), 141-144. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0024-094X%281993%2926%3A2%3C141%3ARO%22NOC%3E2.0Co%3B2-U

Pennsylvania Partnerships for Children. (2006). *Preparing PA youth for success in a 21st century economy: Are we ready?* Retrieved June 20, 2006, from www.papartnerships.org/pdfs/ReadyBy21FactSheet.pdf

Piaget, J. (1962). *Comments on Vygotsky's critical remarks concerning The Language and Thought of the Child, and Judgment and Reasoning in the Child, by Jean Piaget* (A. Parsons, Trans., & E. Hanfmann & G. Vakar, Eds.). Massachusetts Institute of Technology: M.I.T. Press. Retrieved November 7, 2007, from http://www.marxists.org/archive/vygotsky/works/comment/piaget.htm

Pitts Jr., L. (2007, November 18). Is it Hillary's problem, or is it really ours? *Centre Daily Times*, p. E4.

Plucker, J. (2007). *Robert J. Sternberg*. Retrieved October 31, 2007, from http://www.indiana.edu/~intell/sternberg.shtml

Rensing, L., Meyer-Grahle, U., & Ruoff, P. (2001). Biological timing and the clock metaphor: Oscillatory and hourglass mechanisms. *Chronobiology International, 18*(3), 329-369. [Abstract] Retrieved December 10, 2007, from http://www.informaworld.com/smpp/content~content=a713618828~db=all

Reuters. (2002, April 30). *Biological clock starts ticking in late 20s: Study*. Retrieved December 10, 2007, from http://curezone.com/art/read.asp?ID=140&db=1&C0=1

Rice, R. E. (2006, Spring). Enhancing the quality of teaching and learning: The U.S. experience. *New Directions for Higher Education*. Retrieved September 12, 2007, from Academic Search Premier database.

Riehl, E. E. (2005, January 21). Opinion: A glass ceiling for the ivory tower. *The Harvard Crimson Online Edition*. Retrieved October 17, 2007, from http://www.thecrimson.com/article.aspx?ref=505383

Rigoglioso, M. (2004, November). *Good news and bad for women's careers*. Retrieved November 23, 2007, from http://www.gsb.stanford.edu/news/research/ob_womencareers.shtml

Roeser, R. W., Peck, S. C., & Nasir, N. S. (2006). Self and identity processes in school motivation, learning, and achievement. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 391-424). Mahwah, NJ: Lawrence Erlbaum Associates.

Rolison, D. (2007). Title IX assessments of the STEM enterprise. *NSTA Reports, 19*(4), 3.

Rolls, J. (1995). The transformational leader: The wellspring of the learning organization. In S. Chawla & J. Renesch (Eds.), *Learning organizations: Developing cultures for tomorrow's workplace* (pp. 101-108). Portland, OR: Productivity Press.

Rosener, J. B. (1990). Ways women lead. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 149-160). New York: The Free Press.

Ruderman, M. N. (2004, February). Beyond the glass ceiling: Understanding the choices & tradeoffs of high-achieving women. *Leading Effectively*. Retrieved November 20, 2007, from http://www.ccl.org/leadership/enewsletter/2004/FEBglassceiling.aspx?pageId=520

Ruderman, M. N., & Ohlott, P. J. (2002, May). High achievers: Understanding the life and times of today's women managers. *Leading Effectively*. Retrieved November 20, 2007, from http://www.ccl.org/leadership/enewsletter/2002/MAYhighachievers.aspx?pageId=392&AuthorizedRoles=1

Runco, M. A. (1993). Creativity, causality, and the separation of personality and cognition. *Psychological Inquiry, 4*(3), 221-225. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=1047-840X%281993%294%3A3%3C221%3ACCATSO%3E2.0.CO%3B2-V

Sawyer, R. K. (2007). *Group genius: The creative power of collaboration*. New York: Basic Books.

Schein, V. (1989). Would women lead differently? In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 161-167). New York: The Free Press.

Schlechty, P. C. (2002). Making engagement central. In *Working on the work: An action plan for teachers, principals, and superintendents*. San Francisco: Jossey-Bass. Retrieved November 5, 2007, from http://media.wiley.com/product_data/excerpt/55/07879616/0787961655.pdf

Schraw, G. (2006). Knowledge: Structures and processes. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 245-260). Mahwah, NJ: Lawrence Erlbaum Associates.

Science editors' final cut. (2007, October 27). *The Centre Daily Times*, p. A10.

Senge, P., Kleiner, A., Roberts, C., Ross, R., Roth, G., & Smith, B. (1999). *The dance of change: The challenges to sustaining momentum in learning organizations*. New York: Doubleday.

Senge, P. M. (1990). *The fifth discipline*. New York: Doubleday Currency.

Shalley, C. E., Gilson, L. L., & Blum, T. C. (2000). Matching creativity requirements and the work environment: Effects on satisfaction and intentions to leave. *Academy of Management Journal*, *43*(2), 215-223. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0001-4273%28200004%2943%3A2%3C215%3AMCRATW%3E2.0.CO%3B2-3

Shulman, L. (2000). From Minsk to Pinsk: Why a scholarship of teaching and learning? *Journal of Scholarship of Teaching and Learning*, *1*(1), 48-52. Retrieved November 27, 2007, from http://www.iupui.edu/~josotl/VOL_1/NO_1/shulman.v2.pdf

Simon, S. (2008). *Pilot study*. Retrieved February 11, 2008, from http://www.childrens-mercy.org/stats/plan/pilot.asp

Slavin, R. E. (2007). *Educational research in an age of accountability*. Boston: Pearson, Allyn and Bacon.

Smith, J. L., Sansone, C., & White, P. H. (2007). The stereotyped task engagement process: The role of interest and achievement motivation. *Journal of Educational Psychology*, *99*(1), 99-114. Retrieved November 29, 2007, from http://navigator-iup.passhe.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=trh&AN=24157103&site=ehost-live

Smith, K. D., & Thier, S. L. (n.d.). *Considering "Faculty Priorities Reconsidered*." Retrieved November 25, 2007, from http://jdc.jefferson.edu/cgi/viewcontent.cgi?article=1486&context=hpn

Smith, L. M. (1994). Biographical method. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 286-305). Thousand Oaks, CA: Sage Publications.

Sparks, D. (1998, Summer). The educator examined: An interview with Philip Schlechty. We must constantly study ourselves, our work, our institutions. *Journal of Staff Development, 19*(3). Retrieved November 11, 2007, from http://www.nsdc.org/library/publications/jsd/schlechty193.cfm

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications.

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 443-466). Thousand Oaks, CA: Sage Publications.

Stanley, J. C. (1956). The riddle of creativity. *Peabody Journal of Education, 34*(2), 78-81. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0161-956X%28195609%2934%3A2%3C78%3ATROC%3E2.0.CO%3B2-N

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69,* 797-811.

Sternberg, R. J. (1996, November 13). What is 'successful' intelligence? *Education Week*. Retrieved November 18, 2007, from http://www.edweek.org/ew/articles/1996/11/13/11stern.h16.html

Sternberg, R. J., & Lubart, T. I. (1993). Investing in creativity. *Psychological Inquiry, 4*(3), 229-232. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=1047-840X%281993%294%3A3%3C229%3AIIC%3E2.0.CO%3B2-M

Stogdill, R. M. (1948). Personal factors associated with leadership. In J. T. Wren (Ed.) (1995), *Leader's companion: Insights on leadership through the ages* (pp. 127-132). New York: The Free Press.

Summers, L. H. (2005, January 14). *Remarks at NBER conference on diversifying the science & engineering workforce*. Retrieved October 21, 2007, from http://www.president.harvard.edu/speeches/2005/nber.html

Thomas, J. A., & Hairston, R. V. (2003). Adolescent students' images of an environmental scientist: An opportunity for constructivist teaching. *Electronic Journal of Science Education, 7*(4). Retrieved December 1, 2007, from http://ejse.southwestern.edu/original%20site/manuscripts/v7n4/articles/art01_thomas/THOMAS.PDF

Thomas, M. D., Henley, T. B., & Snell, C. M. (2006). The draw a scientist test: A different population and a somewhat different story. *College Student Journal*, *40*(1), 140-148. [Abstract] Retrieved November 29, 2007, from Academic Search Complete database.

Thomson Scientific. (2003, September/October). Twenty years of citation superstars. *ScienceWatch*. Retrieved November 20, 2007, from http://www.sciencewatch.com/sept-oct2003/sw_sept-oct2003

Thomson Scientific. (2005, March). What's new in research: March 28, 2005. *SCI-BYTES.* Retrieved November 20, 2007, from http://www.in-cites.com/research/2005/march_28_2005-2.html

Thomson Scientific. (2007). essential facts. *Essential Science Indicators.* Retrieved November 20, 2007, from http://www.in-cites.com/essential-facts.html

Thomson Scientific. (2007, January). Analysis of... molecular biology & genetics- Using *Essential Science Indicators*. Retrieved November 20, 2007, from http://in-cites.com/analysis/06-fifth-mol.html

Tischler, L. (2004, February). Where are the women? *Fast Company*. Retrieved November 20, 2007, from http://www.fastcompany.com/magazine/79/women.html

United States Equal Employment Opportunity Commission. (2004). *Glass ceilings: The status of women as officials and managers in the private sector*. Retrieved October 17, 2007, from http://digitalcommons.ilr.cornell.edu/key_workplace/87

United States Government Accountability Office. (2004). *Gender issues: Women's participation in the sciences has increased, but agencies need to do more to ensure compliance with Title IX* (Report to Congressional Requesters GAO-04-639). Washington, DC: Author.

Unsworth, K. (2001). Unpacking creativity. *Academy of Management Review, 26*(2), 289-297. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0363-7425%28200104%2926%3A2%3C289%3AUC%3E2.0.CO%3B2-M

U.S. Chamber of Commerce. (2007, February). *Leaders and laggards: A state-by-state report card on educational effectiveness.* Retrieved January 5, 2008, from http://www.uschamber.com/NR/rdonlyres/e6vj565iidmycznvk4ikm3mryxo5nslm7iq2uyrta5vrqdxsagjvkxafz6r3buzaopo4uxv4o4ep4nvhmc3ppc7drjd/USChamberLeadersandLaggards.pdf

U.S. Department of Education. (n.d.a). *Mathematics and science achievement of eighth-graders between 1995 and 2003*. Retrieved June 29, 2006, from http://nces.ed.gov/timss/Results03.asp?Quest=4

U.S. Department of Education. (n.d.b). *Mathematics and science achievement of eighth-graders in 2003*. Retrieved June 29, 2006, from http://nces.ed.gov/timss/Results03.asp?Quest=3

Van de Walle, J. A. (2004). *Elementary and middle school mathematics: Teaching developmentally* (5th ed.). Boston: Pearson.

van Teijlingen, E. R., & Hundley, V. (2001, Winter). The importance of pilot studies. *social research UPDATE*, (35). Retrieved February 11, 2008, from http://sru.soc.surrey.ac.uk/SRU35.pdf

von Glasersfeld, E. (2005). Introduction: Aspects of constructivism. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (2nd ed., pp. 3-7). New York: Teachers College Press.

Vygotsky, L. (1926). The problem of giftedness: Individual goals of education, personality and education. In R. Silverman (Trans.) (1992), *Educational Psychology*. Florida: St. Lucie Press. Retrieved November 11, 2007, from http://www.marxists.org/archive/vygotsky/works/1926/educational-psychology/index.htm

Vygotsky, L. (1929). *The problem of the cultural development of the child*: *The problem*. Retrieved November 11, 2007, from http://www.marxists.org/archive/vygotsky/works/1929/cultural_development.htm (Original work first published as Vygotsky, L. S. 1929: The problem of the cultural development of the child II. *Journal of Genetic Psychology, 3*6, 415-432)

Want organic food? (2009, March 29). *York Sunday News*, p. B1.

Wasley, P. (2007a, November). Faculty-productivity index offers surprises: Third annual ranking gives high marks to some lesser-known programs. *The Chronicle of Higher Education*, *54*(12), A10. Retrieved November 12, 2007, from http://chronicle.com/weekly/v54/i12/12a01001.htm

Wasley, P. (2007b, November). 'Professors of the year' gauge best ways to inspire students to learn technical disciplines. *The Chronicle of Higher Education*. Retrieved November 18, 2007, from http://chronicle.com/daily/2007/11/732n.htm

Weiser, C. J. (1996, March). *The value system of a university- Rethinking scholarship*. Retrieved November 25, 2007, from http://www.adec.edu/clemson/papers/weiser.html

Welle, B., & Heilman, M. E. (2005). *Formal and informal discrimination against women at work: The role of gender stereotypes* [Working Papers, Center for Public Leadership]. Retrieved November 18, 2007, from http://www.ksg.harvard.edu/leadership/images/stories/ksg/PDF/Publications/welleheilmanworkingpaper.pdf

Williams June, A. (2007, December 6). Tenure at MIT still goes mainly to men. *The Chronicle of Higher Education News Blog*. Retrieved December 10, 2007, from http://chronicle.com/news/article/3574/tenure-at-mit-still-goes-mainly-to-men

Willoughby, S. S. (1983/1984). Mathematics for 21st century citizens. *Educational Leadership*. Retrieved December 3, 2007, from http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_198312_willoughby.pdf

Woken, M. D. (n.d.). *Advantages of a pilot study* (Planning Research Papers 7). Springfield, IL: University of Illinois, Center for Teaching and Learning. Retrieved February 12, 2008, from http://www.uis.edu/ctl/writing/documents/ctlths7.pdf

World Economic Forum. (2006). *Annual meeting 2006: The creative imperative*. Retrieved November 11, 2006, from http://www.weforum.org/pdf/summitreports/am2006/future.htm

York, C. D. (2005). Leadership effectiveness: Investigating the influences of leader sex, gender, and behaviors on self and other perceptions. Ph.D. dissertation, University of North Texas. Retrieved October 28, 2007, from Dissertations & Theses: Full Text database. (Publication No. AAT 3206139)

Zhou, J., & George, J. M. (2001). When job dissatisfaction leads to creativity: Encouraging the expression of voice. *Academy of Management Journal*, *44*(4), 682-696. Retrieved October 23, 2007, from http://links.jstor.org/sici?sici=0001-4273%28200108%2944%3A4%3C682%3AWJDLTC%3E2.0.CO%3B2-A

Biographical Bibliography

Alonzo, A. (1963, June 25). TWU's Dr. Bateman finds time for many extracurricular duties. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Becka, H. (1994, August 1). Dream space: Educators remember TWU's efforts in manned flight. *Denton Record-Chronicle*, p. 5A. [The Women's Collection, Texas Woman's University, Denton, Texas]

Beery, P. G. (1922). A practical course in household chemistry. Bloomington, Illinois: Public School Publishing Company (Reprinted from *Journal of Educational Research*, *5*(2), 125-134) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Beery, P. G., & Willard, M. L. (1923, March). A history of dyes: Introduction. *The Journal of Home Economics*, *XV*(3), 105-110. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Beery, P. G., & Willard, M. L. (1923, April). A history of dyes: The adaptive period (continued from March). *The Journal of Home Economics*, *XV*(4), 193-195. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Beery, P. G., & Willard, M. L. (1923, May). A history of dyes: The creative period (continued from April). *The Journal of Home Economics*, *XV*(5), 262-270. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Benfey, T. (2003). Visions, achievements, and challenges of the Division of Chemical Education during the early years. *Journal of Chemical Education, 80*(6), 651. Retrieved November 25, 2007, from http://adsabs.harvard.edu/abs/2003JChEd.80.651B

Big D Chapter to observe National Secretaries Week. (1954, May 16). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Biosatellite III/Primate Capsule. (n.d.). Retrieved February 22, 2009, from http://lis.arc.nasa.gov/lis/Experiment_App/BIO3_3_4.html

Bone mass lost in space, dietitians hear. (1966, March 19). [The Women's Collection, Texas Woman's University, Denton, Texas]

Born in the fall? You're lucky! (1940, November 1). *Daily Collegian*, p. 8. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Brill, J. G. (1934). Here and there with the girls: Penn State in the new deal. *Penn State Alumni News, 22*(1), pp. 8-9. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Brinkerhoff, M. (1964, April 1). Whew! Lady Bird leads classy academic pace. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Broadcast on research and children's diets: Report on studies in human nutrition in progress in Pennsylvania [Radio broadcast transcript]. (1938, April 20). Philadelphia: KYW. (Reprinted from *The Science Leaflet*) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Brown, W. N. (1949, September). *Bone density computing machine*. Paper presented at the Fifth Annual National Electronics Conference, Chicago, IL. [The Women's Collection, Texas Woman's University, Denton, Texas]

Buffet supper fetes Dr. Mack. (1949, January 28). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Bullock, H. (1958, May 28). Diet found to help problems of aged. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Case, L. D. (1949). The Wetzel Grid chart: Something new in the field of guidance. *Association Boys' Work Journal, Y.M.C.A., 23*(1), 8-9. [Reprint] [The Women's Collection, Texas Woman's University, Denton, Texas]

Cawley, C. N., & Mack, P. B. (1971). Comparing sling & loose laundered linen. *Institutional Laundry*, *15*(9), 22-25. [The Women's Collection, Texas Woman's University, Denton, Texas]

Centre Daily Times. (1948, September 11). (Phi Beta Kappa election) [Pennsylvania State University Archives, ABVF Mack, W. B.]

Cerebral and polio diet vital. (1956, May 9). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Certificate of death: Pauline Beery Mack. (1974, October 22). Texas: County of Denton.

Chambers, R. W. (1974). *Dr. Mack obit*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Chem fraternity honors president. (1948, December 3). *Daily Collegian*. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Chemist, research director, editor. (1944, November). *Chemistry*, 58-60. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Chemistry study urged for women: Convention in September will aim to create its better understanding among them. (1930, July 20). *New York Times*, p. N3. Retrieved January 31, 2008, from Proquest Historical Newspapers, The New York Times (1851-2004) database. (Document ID 107111614)

Cited as teacher and research director: Former University chemist given distinguished award. (1959, December 28). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Coeds reorganize chemical society. (1947, November 5). *Daily Collegian*, p. 1. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Cohen, B., & Mack, P. B. (1936, April-June). Part IV. The effect of water-washing upon the strength of unweighted silks. *Rayon and Melliand Textile Monthly*.

College assists Victory Gardens, sponsors class. (1942, January 24). *Daily Collegian*, p. 1. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

College of Household Arts planning research program. (1952, March 19). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

College research assistant dies. (1951, February 24). *Daily Collegian*, p. 3. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

The College suffers a real loss. (1951, September 5). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

College to honor noted women at commencement. (1952, June 2). *Easton Express*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Consumers advise business of needs: Product labels and more data in ads recommended at joint session here. (1940, May 14). *New York Times*, p. 38. Retrieved January 31, 2008, from Proquest Historical Newspapers, The New York Times (1851-2004) database. (Document ID 93975963)

Convention slated by Dairy Institute. (1953, February 15). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Cotton as source of food studied by research group. (1971, September 10). *The Daily Lass-O*, p. 3. [The Women's Collection, Texas Woman's University, Denton, Texas]

Coughlin, W. E. (1931, August). Reactions of silk fibroin with solutions of stannic chloride and disodium phosphate. (Reprinted from *Journal of Physical Chemistry*, *XXXV*, pp. 2434-2445) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Crosby, K. (1972, May 26). Pauline fights perils with research. *The Dallas Morning News*, Section C. Retrieved August 11, 2008, from http://infoweb.newsbank.com [Also in The Women's Collection, Texas Woman's University, Denton, Texas]

Dairy group asked to set up research. (1953, February 25). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Dean, E. (n.d.). *From a woman's corner- Eminent authority arrives at TSCW*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Dean Mack to speak before TSCW ex-student groups. (1952, March 17). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Dean Mack tours with Operation Understanding. (1960, December 7). *Daily Lass-O, 47*, p. 1 (Special Civil Defense Supplement). [The Women's Collection, Texas Woman's University, Denton, Texas]

Dedication ceremony scheduled at TSCW. (1952, March 23). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Denton rites held for TWU official. (1974, October 25). *The Dallas Morning News*. [The Women's Collection, Texas Woman's University, Denton, Texas]

DiMarco, N. M., Bonnick, S. L., Cox, A. J., & DeVries, E. (n.d.). *Relationship between dietary intake and bone mineral density in postmenopausal women: A 20-year study*.

Diocese of Harrisburg. (1920, April 11). *Confirmation certificate: P. G. Beery*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Discuss health benefits of citrus. (1954, March 11). *Lakeland Ledger*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Discuss pre-shrinking: Consumer spokesmen heard at women's conference. (1937, March 31). *New York Times*, p. 30. Retrieved January 31, 2008, from Proquest Historical Newspapers, The New York Times (1851-2004) database. (Document ID 94347598)

D'Olier, A. A., & Mack, P. B. (1932, February). Effect of storage in the dark on the breaking strength of weighted and unweighted silks. (Reprinted from *Journal of Home Economics, 24*(2), pp. 165-170) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Mack honored in retirement. (1971, October 28). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Mack named in Who's Who. (1973, September 6). *The Daily Lass-O*, p. 3. [The Women's Collection, Texas Woman's University, Denton, Texas]

Dr. Mack receives honorary degree: Gen Eisenhower present at ceremony. (1946, November 21). *Collegian*. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Dr. Mack recognized. (1971, September 8). *The Daily Lass-O*, p. 1. [The Women's Collection, Texas Woman's University, Denton, Texas]

Dr. Mack to leave for Texas post. (1951, August 31). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Mack to receive Garvan Medal for outstanding research in bone density. (1950, April 13). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Pauline Beery Mack accepts dean's post at Texas Women's College. (1951, October 30). *Alumni News, 38*(2). [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Pauline Mack named dean of home economics at TSCW. (1951, August 16). *The Denton Record-Chronicle*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Dr. Pauline Mack to address group. (1955, October 23). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Dr. Pauline Mack to speak Thursday at Health Museum. (1953, October 25). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Dr. Warren B. Mack. (n.d.). [Pennsylvania State University Archives, ABVF Mack, W. B.]

Engleman, M. (1964, January 26). Your bones: How strong? A massive Denton project may give answer. *The Denton Record-Chronicle*, Section 3, p. 2. [The Women's Collection, Texas Woman's University, Denton, Texas]

English, S. (1953, June 5). Teen-agers' narcotic, poor-eating problems outlined for teachers. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

English, S. (1953, October 16). Museum sets drive on eating. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

English, S. (1953, October 30). Self-imposed reducing diet called health hazard by nutrition expert. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

English, S. (1955, November 9). Research shows diet provides better skin. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Experts test ‘war coat’: See substitutes at victory forum. (1942, March 26). *The Philadelphia Inquirer*, pp. A1, 23. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Eyrich, C. (1963, March 2). Dr. Mack saving money for Texas. *Star-Telegram*. [The Women’s Collection, Texas Woman’s University, Denton, Texas]

Folkenroth, N. (1991, March). She took science by storm. *Town & Gown*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Football letter. (1943, September 20). State College, Pennsylvania: The Penn State Alumni Association.

Forbes, W. M., & Mack, P. B. (1929, November). The effect of tin weighting on the nitrogen content and physical properties of silk. (Reprinted from *Journal of Home Economics, 21*(11), pp. 841-855) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Forbes, W. M., & Mack, P. B. (1935, December-1936, January). The effect of the tin-weighting process on the strength of new silk- Paper I. (Reprinted from *Rayon and Melliand Textile Monthly*, December 1935-January 1936) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Fort Worth OK’s air ruling plea. (1964, April 14). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Four area scientists to get space honors. (1970, April 23). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Garvan Medal for Mrs. Mack. (1949, September 24). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Garvan Medal to Pauline Mack. (1950, March 27). *Chemical and Engineering News*, p. 1032. [Pennsylvania State University Archives, ABVF Mack, P. B.; The Women's Collection, Texas Woman's University, Denton, Texas]

Growing field in home ec: Dr. Mack reviews decade of research at TWU. (1962, March 16). *The Denton Record-Chronicle*, p. 5. [The Women's Collection, Texas Woman's University, Denton, Texas]

Hale, M. D., & Mack, P. B. (1936, April-June). The effect of various dry cleaning solvents on unweighted and on tin weighted silks- Paper V. (Reprinted from *Rayon and Melliand Textile Monthly*, April, May, June 1936) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Harris, L. (1963, May 16). T.W.U. scientist Dr. Mack to head project for NASA. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Harris, L. (1964, April 3). Four aid space study by enforced 'bed rest.' *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Has your child half a hog's chance? (1944, October). *Ladies Home Journal* (Reprint). [Pennsylvania State University Archives, ABVF Mack, P. B.]

Henderson, A. (n.d.). *Harry B. Henderson Jr. 1914-2003*. Retrieved January 28, 2008, from http://harryhenderson.com/harry_henderson-biopage.html

Hetzel, R. D. (1946, December 6). *Letter to Dr. Pauline Beery Mack*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Historical markers of Denton County. (2002, June 2). Denton, Texas: Denton County Historical Commission.

Hollcroft, T. R. (1937). The summer meeting in State College. *Bulletin of the American Mathematical Society, 43*(11), 745-757. Retrieved December 6, 2007, from http://projecteuclid.org/euclid.bams/1183500093

Holtzinger to talk to Altrusa Club. (1952, January 19). *Daily Collegian*, p. 3. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Homestead workshop session set at Denton. (1955, March 12). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Hotel curriculum. (1941, February 3). *Daily Collegian*, p. 1. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Household arts and sciences research division: New 'industry' arrives. (n.d.). [The Women's Collection, Texas Woman's University, Denton, Texas]

Instructor at TSCW accorded new honor. (1953, May 10). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Jones, D. W. (2006). *Punched cards: A brief illustrated technical history* [Part of the Punched Card Collection]. Retrieved January 31, 2009, from http://www.cs.uiowa.edu/~jones/cards/history.html

Jones, M. V. (1949, August 6). *A study of artificial perspiration applied by different methods to rayon fabrics*. Unpublished doctoral dissertation, Pennsylvania State College, State College.

Kerr, B. (1965, December 12). TWU team studying bone tissue of Gemini astronauts. *The Denton Record-Chronicle*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Kurilla, J. A. (1971, February 18). Switching courses key to long career: Ex-University professor aids space program. *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Last will and testament: Pauline Beery Mack. (1974, May 1). [Filed in County Court, Denton, Texas in November 1974, No. 8009, Vol. 138, p. 670]

Laundry owners to convene here Thursday, Friday. (1935, May 14). *Penn State Collegian, 31*(59), p. 1. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Legislature. (1941, May 3). *Daily Collegian*, pp. 1-2. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Lipitor. (2006-2008). Retrieved February 19, 2009, from http://www.lipitor.com/about-lipitor/benefits.jsp?source=google&HBX_PK=s_hdl+levels&HBX_OU=50&o=23127370|166376222|0

Lovell, J. (1970, March 24). *Letter to Dr. Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Lowther, M. E., Mack, P. B., Logan, C. H., O'Brien, A. T., Smith, J. M., & Sprague, P. K. (1940, September). The school lunch as a supplement to the home diet of grade school children. (Reprinted from *Child Development, 11*(3), pp. 203-247) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack addresses health workshop. (1959, December 15). *Alumnae Bulletin, 582*, p. 3. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack elected to British Royal Society. (1958, February 20). *Daily Lass-O*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B. (1932). *A quantitative study of the effects of radiant energy from different parts of the spectrum on ossification and growth*. Unpublished doctoral dissertation, The Pennsylvania State College, State College. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B. (1934, May). Clothing and household goods for the consumer. *The Annals of the American Academy of Political and Social Science,* 35-42. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B. (1941). The Ellen H. Richards Institute. (Reprinted from *Journal of Home Economics*, *33*(4), pp. 229-232) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B. (1944, March 24). *Letter to Miss Gladys H. Cranmer, Assistant Librarian, Pennsylvania State University*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B. (1952, April 25). *Letter to Mr. B. Clark Prescott, Coin Operated Laundries & Equipment, Tacoma, Washington*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B. (1964, December 6-28). *To my many dear friends* (Letter). [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B. (1969). Automated techniques in bone densitometry. *Journal of the Association for the Advancement of Medical Instrumentation*, *3*(3), 110-115.

Mack, P. B. (1970, August). Radiographic measurements of changes in bone calcium content (density). *CRC Critical Reviews in Radiological Sciences,* 473-522.

Mack, P. B. (1971). *Christmas 1971* (Letter). [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B., Beaushene, R. E., Kinard, C. L., Campbell, H. B., Vose, G. P., & Kubala, A. L. (1958, July). *A nutrition study involving the feeding of orange juice to pre-school and elementary school children* (Bulletin No. 4, Human Nutrition Series). Denton, Texas: Texas Woman's University, College of Household Arts and Sciences.

Mack, P. B., Brown, W. N., & Trapp, H. D. (1949, June). The quantitative evaluation of bone density. (Reprinted from *The American Journal of Roentgenology and Radium Therapy*, *LXI*(6), 808-825) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., Lachance, P. A., Vose, G. P., & Vogt, F. B. (1967). *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*, *100*(3). Retrieved January 28, 2008, from http://www.ajronline.org/cgi/reprint/100/3/503

Mack, P. B., & Lachance, P. L. (1967). Effects of recumbency and space flight on bone density. *The American Journal of Clinical Nutrition*, *20*(11), 1194-1205. Retrieved January 28, 2008, from http://www.ajcn.org/cgi/reprint/20/11/1194

Mack, P. B., & Mack, W. (1942). Home dehydration and wartime conservation of fruits and vegetables. *The Pennsylvania State College Bulletin*, *36*(36). (Reprinted from *The Chemistry Leaflet*) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., O'Brien, A. T., Smith, J. M., & Bauman, A. W. (1939). A method for estimating the degree of mineralization of bones from tracings of roentgenograms. (Reprinted from *Science*, *89*(2316), p. 467) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., & Osterling, J. F. (1945, March). Textile chemistry at The Pennsylvania State College. *Pennsylvania Labor & Industry Review: Textiles*, 7-18. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., Smith, J. M., Logan, C., O'Brien, A. T., Dattner, A., & Bauman, A. W. (n.d.). *Pennsylvania mass studies in human nutrition* [Report]. State College, PA: Pennsylvania State College.

Mack, P. B., Smith, J. M., Logan, C. H., O'Brien, A. T., Shaw, J. J., & Dodds, P. (1941). Hemoglobin values in Pennsylvania mass studies in human nutrition. (Reprinted from *The Milbank Memorial Fund Quarterly*, *19*(3), pp. 282-303) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., & Stover, H. W. (1936). *Laundry practice and customer relations: The satisfied customer* (Extension Series Book No. 15). State College, PA: The Pennsylvania State College, Extension Services. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B., & Urbach, C. (1949). *A study of institutional children with particular reference to the caloric value as well as other factors of the dietary*. Washington, DC: Society for Research in Child Development, National Research Council. (Reprinted from *Monographs of the Society for Research in Child Development, XIII*(1), Serial No. 46, 1948) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., Urbach, C., Stewart, A. H., & Dodds, P. (1944). A study of the breakfast habits of 5000 persons with particular reference to cereal consumption (Ellen H. Richards Institute Research Series, Publication No. 3). *The Pennsylvania State College Bulletin, 38*(31). [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. B., Vose, G. P., & Nelson, J. D. (1959). New development in equipment for the roentgenographic measurement of bone density. *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, 82*(2). [Reprint] [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, P. B., Wenger, H. N., Mosteller, R. J., and Baer, M. T. (1937). A method for measuring the efficiencies of laundry procedures (Home Economics Research Series Publication Number 2). *The Pennsylvania State College Bulletin, 31*(30). [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, P. G. B. (1931). *Calcium carbide and acetylene* (4th ed.) [Bulletin]. State College, PA: The Pennsylvania State College School of Physics and Chemistry. (Rewrite of original work by G. G. Pond published in 1899, 1909, 1917) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack receives Piper Award. (1959, December 22). Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack receives Snoopy. (1970, April 28). *The Daily Lass-O*, p. 1. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, Sherrill direct national research program. (1955, August 1). *College Alumnae Bulletin.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack to give Priestley talk. (1951, May 8). *Daily Collegian*. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Mack, W. (1949, April 7). *Biographical material about Pauline Beery Mack, director of the Ellen H. Richards Institute, professor of textile chemistry*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Mack, W. B., Dutcher, R. A., & Mack, P. B. (n.d.). *Conserving Victory Garden products*.

Mack, W. B., & Mack, P. B. (1942, November 22). Revealing health value of apples as source of many vitamins and toxin absorbent. *Everybody's Weekly, The Philadelphia Inquirer*, p. 7. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, W. B., & Mack, P. B. (1949a, September 8). *Invitation to reception at residence*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mack, W. B., & Mack, P. B. (1949b, September 8). *Invitation to 25th wedding anniversary celebration*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mayhem in Medford. (1942, December 21). *Time*, p. 78.

McDonald, F. L. (1951, August 15). *TSCW names dean of college of household arts and sciences*. (Special to: Denton Record-Chronicle; Release Thursday 8-16-51). Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

McDonald, F. L. (1951, August 16). *Dr. Pauline Beery Mack named dean of TSCW'S College of Household Arts and Sciences.* Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

McDonald, F. L. (1951, August 20). *Exclusive to Dallas Morning News*. Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Memorial record for friends and relatives. (1952, July 9). State College, PA: Koch Funeral Home. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Millinder guilty of Gates' Murder. (1940, September 16). *Daily Collegian*, p. 1. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Minutes for meeting (Book 50, pp. 10-14). (1952, June 2). Denton, Texas: Texas State College for Women, Board of Regents. [The Women's Collection, Texas Woman's University, Denton, Texas]

Minutes for meeting (Book 50, pp. 15-18). (1952, June 23). Denton, Texas: Texas State College for Women, Board of Regents. [The Women's Collection, Texas Woman's University, Denton, Texas]

Moms could do better job of feeding their families. (1969, October 13). *Denton Record-Chronicle*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Monkey goes into space: TWU assists in NASA project. (1971, February 3). [The Women's Collection, Texas Woman's University, Denton, Texas]

Moon, M. (1967, May 5). *TWU's space studies valuable to NASA: Bed-rest technique is calcium study backbone*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Moore, J. W. (2004). A chemistry leaflet for today's students. *Journal of Chemical Education*, *81*(11), 1543. Retrieved January 4, 2009, from http://jchemed.chem.wisc.edu/journal/Issues/2004/Nov/abs1543.html

Moore, W. B. (1963, December 12). Texas scientist: Woman in space. *Morning News*. Dallas, Texas: Texas Press Clipping Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Moore, W. B. (1973, May 28). Aiding Texas Farmers: Denton orphans test new food. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Morrison, B. V., Fletcher, H. M., Mack, P. B., Morse, E. C., Phelps, E. L., & Stout, E. E. (1946). How the war affected civilian textiles. *Journal of Home Economics*, *38*(1), 21-30. (Reprint) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Mrs. John P. Beery obituary. (1947, January 2). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Musical program by Glee Club and Junior Choir: In honor of twenty-five years of marriage, Warren and Pauline Beery Mack. (1949, September 8). Cresson, PA: Saint Mary's School. [Pennsylvania State University Archives, ABVF Mack, P. B.]

NASA awards 2nd grant to TWU for space studies. (1963, December 1). *The Denton Record-Chronicle*, p. 8. [The Women's Collection, Texas Woman's University, Denton, Texas]

NASA long term immobilization research at TWU. (1964, June 29). Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

New technique urged to speed housework. (1951, June 23). *Special to The New York Times*, p. 18. Retrieved January 31, 2008, from Proquest Historical Newspapers The New York Times (1851-2004) database. (Document ID 91642805)

Notes from Loanne Snavely, head of instructional programs, interview- Warren Mack. [Pennsylvania State University Archives, ABVF Mack, W. B.]

October-November babies. (1940, October 4). State College, Pennsylvania: The Pennsylvania State College, Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Official Texas historical marker dedication commemorating the first building of the Texas Woman's University [Program presented by The Past Presidents' Council of the Alumnae Association and the Denton County Historical Survey Committee]. (1974, April 26).

On nutrition in South. (1944, January 14). *Daily Collegian*, p. 3. Retrieved December 30, 2008, from http://digitalnewspapers.libraries.psu.edu

Osterling, J. F., & Mack, P. B. (1936, July). Research groups study peroxide clarifier. (Reprinted from *Laundry Age*, July 1936) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Osterling, J. F., & Mack, P. B. (1936, August). More about bleaching. (Reprinted from *Laundry Age*, August 1936) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Pauline. (2007). Retrieved December 6, 2007, from http://www.babynamer.com/Pauline

Pauline B. Mack, research leader, dies in hospital. (1974, October 22). *The Daily Lass-O*, pp. 1, 3. [The Women's Collection, Texas Woman's University, Denton, Texas]

Pauline Beery Mack. (1976). *TWU Alumnae*, *2*(111), p. 5. [The Women's Collection, Texas Woman's University, Denton, Texas]

Pauline Beery Mack fifty year follow-up study. (Fall, 2006). *Institute for Women's Health, Texas Woman's University*, p. 2. Retrieved January 22, 2008, from http://twu.edu/womenshealth/Newsletter%20Fall%202006_PDF.pdf

Pauline Beery Mack project. (2007, November 15). *Institute for Women's Health, Texas Women's University*. Retrieved January 22, 2008, from https://www.twu.edu/womenshealth/projects_paulinebeerymack.htm

Paxar Corporation. (2001, January). *From concept to checkout*. Retrieved January 10, 2009, from http://www.paxar.com/carelabel/.

Penn State woman chemist named on textile committee. (1928, July 20). *D.C. Times*.

Phelps, R. A. (1962, July 24). *Letter to Dr. Pauline Beery Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Philips, C. R., & Mack, P. B. (1936, April-June). Part III. Practical dry cleaning trials of miscellaneous silks. *Rayon and Melliand Textile Monthly*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Pines, M. (1950, April 21). American meals badly balanced. *Boston Globe*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Program. (1954, March). Lakeland, Florida: Conference on Research in Medicine and Nutrition, Florida Citrus Commission. [The Women's Collection, Texas Woman's University, Denton, Texas]

Programs held in honor of the dedication of a new building and the inauguration of an expanded program for the College of Household Arts and Sciences. (1952, March). Denton, Texas: Texas State College for Women.

Pyle, K. (1993, March 9). *Dr. Betty Alford, an oral history: Interview about Dr. Pauline Beery Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Pyle, K. (1993, March 11). *Jessie Ashby, an oral history: Interview about Dr. Pauline Beery Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Pyle, K. (1993, April 2). *Esther Broome, an oral history*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Pyle, K. (1993, April 15). *Bill Stover, an oral history regarding former TWU faculty member Dr. Pauline Beery Mack*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Pyle, K. (1993, April 16). *Gertrude Adams Lathrop, an oral history: Reminiscence of Dr. Pauline Beery Mack*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Raber, L. (2008). 1929: Francis P. Garvan (1875-1937). *Chemical & Engineering News Special Issue: 85th Anniversary of the Priestley Medal*, *86*(14). Retrieved January 10, 2009, from http://pubs.acs.org/cen/priestley/recipients/1929garvan.html

Radiation research: Group from TWU to give papers. (1968, November 20). [The Women's Collection, Texas Woman's University, Denton, Texas]

Ramsay, E. C., & Mack, P. B. (1936, February-March). The effect of dry cleaning and of water washing on the strength of unweighted and of tin weighted silk. Part I. The effect of dry cleaning, stains, stain removal agents, and pressing. (Reprinted from *Rayon and Melliand Textile Monthly*, February & March, 1936) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Rauber, A. (1990). Growth and development. In H. K. Walker, W. D. Hall, & J. Willis Hurst (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed.). Retrieved February 20, 2009, from http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=cm&part=A6466

The relationship of science to children's health [Radio broadcast transcript]. (1936, November 19). NBC Red Network: WEAF and affiliated stations. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release on Friday. (1952, June 13). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Release on Saturday. (1949, September 24). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release on Sunday. (1951, May 6). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release on Thursday. (1947, January 2). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release on Thursday. (1948, September 9). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Release on Tuesday. (1949, August 2). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release to PMs Wednesday. (1952, June 18). State College, Pennsylvania: The Pennsylvania State College, Public Information Department. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Release to PMs Wednesday. (1955, November 10). State College, Pennsylvania: The Pennsylvania State College, Public Information Department. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Release Tuesday. (1959, December 29). State College, Pennsylvania: The Pennsylvania State College, The Department of Public Information. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Release Wednesday. (1953, May 6). [Pennsylvania State University Archives, ABVF Mack, W. B.]

Release Wednesday. (1962, July 10). [Pennsylvania State University Archives, ABVF Mack, W. B.]

Research making cotton important food source, too. (1971, June 6). *Denton Record-Chronicle,* p. 1A. [The Women's Collection, Texas Woman's University, Denton, Texas]

Researchers will conduct home laundry care course. (1967, October 22). *Dallas Times Herald*, p. D9. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler. (*Press release on Western College honorary degree*). (1952). Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler. (*to RC Press release on Moravian honorary degree*). (n.d.). Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1953, September 29). *TSCW scientists to speak in San Antonio*. Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1954, March 15). *Texas State College for Women research scientist reports on value of orange juice in teen-age diet*. Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1954, December 21). *Dr. Mack research*. Denton, Texas: TSCW News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1959, December 22). *Letter to Mr. W. F. Ackerman, Editor, Faculty Bulletin, Pennsylvania State University*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1962, August 9). *Dr. Mack story*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1964, June 26). *TWU gets $90,000 NASA grant*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1964, December 29). *TWU story… First half of the 1960's*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1970, March 12). *Texas Woman's University prepares for next space program.* Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Rigler, F. C. (1970, April 23). *To Frank Lightfoot*. Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

Roberts, N. M., & Mack, P. B. (1932, February). A study of the effects of light and air on the physical properties of weighted and unweighted silks. (Reprinted from *Journal of Home Economics*, *24*(2), pp. 151-165) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Roberts, N. M., & Mack, P. B. (1932, June). The effect of weighting on the air permeability of silk. (Reprinted from *Journal of Home Economics*, *24*(6), pp. 539-543) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Rossiter, M. W. (1982). *Women scientists in America: Struggles and strategies to 1940* (Vol. 1). Baltimore: Johns Hopkins University Press.

Ross-Nazzal, J. (2006, May 4). *NASA Johnson Space Center Oral History Project Oral History Transcript: Paul A. Lachance.* Retrieved October 17, 2007, from http://www.jsc.nasa.gov/history/oral_histories/participants.htm

Royal Society of Chemistry. (2009). *Conversations on chemistry by Jane Marcet 10th ed 1825*. Retrieved January 11, 2009, from http://www.rsc.org/Library/LICHelp/HistoricalChemistry/Conversations/

School health unit schedules meeting. (1955, March 4). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Shearer, B. F., & Shearer, B. S. (Eds.). (1997). *Notable women in the physical sciences: A biographical dictionary.* Westport, Connecticut: Greenwood Press.

Simpson, G. (1958, July 5). TWU grows in reputation for lead in fabric research. *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Sputnik and the dawn of the space age. (2007, October 10). Retrieved February 16, 2009, from http://history.nasa.gov/sputnik/

Stout, L. (2007, March). CSI pioneer was an influential, beloved figure. [Excerpted from *Town & Gown*] Retrieved December 30, 2008, from http://www.science.psu.edu/journal/Spring2007/AlumPhilanthSpr07.htm

Student enrollments: 1903-1960. (2002, April 30). Denton, Texas: Texas Woman's University, Office of Institutional Research. [The Women's Collection, Texas Woman's University, Denton, Texas]

Study of calcium loss in space slated at TWU. (1963, May 26). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Suggests ad groups keep eye on critics: Unfavorable trends should be detected in advance, Dr. H. T. Hovde says. (1937, October 1). *New York Times*, p. 30. Retrieved January 31, 2008, from Proquest Historical Newspapers, The New York Times (1851-2004) database. (Document ID 94432788)

Taylor, B. L. (1919, October 8). *Letter to P. B. Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Taylor, B. L. (1919, November 9). *Letter to P. B. Mack.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Terror continues. (1942, December 21). *Time*, p. 78.

Tests reveal nutritional deficiencies. (1948, July 6). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Texas Dietetic Association to stage 3-day convention. (1954, March 31). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Texas Woman's University. (2001, December 10). *The Handbook of Texas Online*. Retrieved December 6, 2007, from http://www.tsha.utexas.edu/handbook/online/articles/TT/kct37.html

Texas Woman's University cooperates in a complex biosatellite research program. (1969, April 24). Denton, Texas: TWU News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

THDA holds district conclave. (1969, March 25). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Thompson, J. (1982). *Marking a trail: A history of the Texas Woman's University*. Denton, Texas: Texas Woman's University Press.

TSCW dean to get degree at Moravian. (1952, June 7). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TSCW pioneers household field again with building dedication. (1952, March 28). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TSCW reunion begins Friday. (1952, May 25). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TSCW to confer first doctorates. (1953, May 29). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TSCW's 50th anniversary brings pledge of new gains. (1952, November 7). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TWU at Denton provides wide variety of fields in education. (1959, May 10). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TWU dean asked to join medical abstract group. (1960, January 8). *Denton Record Chronicle*. [The Women's Collection, Texas Woman's University, Denton, Texas]

TWU given NASA grant. (1964, June 28). *The Denton Record-Chronicle*. [The Women's Collection, Texas Woman's University, Denton, Texas]

TWU research team took part in flight of Apollo 8. (1968, December 29). *The Denton Record-Chronicle*. [The Women's Collection, Texas Woman's University, Denton, Texas]

TWU sets record for spring semester enrollment. (2007, February 1). Retrieved February 14, 2009, from http://www.twu.edu/TWUNEWS/press_releases/07springenroll.htm

TWU students given Maid of Cotton trials. (1959, November 20). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

TWU's Dr. Pauline Beery Mack elected to Royal Society of Health of Great Britain. (1958, February 21). Denton, Texas: Texas Woman's University News Bureau. [The Women's Collection, Texas Woman's University, Denton, Texas]

TWU's standing illustrated: Work of Mack and Duggan Cited. (1958, November 19). *Daily Lass-O*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Vegetables and fruits in relation to human nutrition in wartime: Nutrition- and gardens for victory. (1942). *The Pennsylvania State College Bulletin, 36*(28). State College, Pennsylvania: Nutrition Sub-Committee, Advisory Victory Garden Committee, Pennsylvania State Council of Defense. (Reprinted from *The Chemistry Leaflet*) [Pennsylvania State University Archives, ABVF Mack, P. B.]

Victory Garden Committee. (1944, April). *Victory Gardens handbook of the Victory Garden Committee.* War Services, Pennsylvania State Council of Defense. Retrieved November 27, 2007, from http://www.earthlypursuits.com/VictoryGardHandbook/VGH8.htm

Vose, G. P. (1974). Review of roentgenographic bone demineralization studies of the Gemini space flights. *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*, *121*(1), 1-4.

Vose, G. P., & Engel, A. (1973). Relationship of radiographic cortical thickness vs. age in thirteen bones of the hand. *Journal of Gerontology*, *28*(1), 46-49.

Warren B. Mack, 56, dies in Philadelphia hospital. (1952, July 7). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, W. B.]

Warren Mack will retire after 30 years at College. (1952, June 13). *Centre Daily Times*. [Pennsylvania State University Archives, ABVF Mack, W. B.]

W. B. Mack succumbs to heart attack. (1952, July 7). [The Women's Collection, Texas Woman's University, Denton, Texas]

W. B. Macks observe 25th year of marriage; 300 guests attend. (1949, September 13). *Centre Daily Times.* [Pennsylvania State University Archives, ABVF Mack, P. B.]

Weight control series set at Health Museum. (1954, February 4). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Weight control talk slated at Health Museum. (1954, March 17). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Westinghouse. (1949, January 27). *Americans gamble with health, family nutrition project shows*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Wetzel, N. C. (1962, October 30). *Letter to Pauline Beery Mack, Ph.D.* [The Women's Collection, Texas Woman's University, Denton, Texas]

Where are they now? (1978, November). *The Pioneer*, *1*(11), p. 3.

Willard, M. L. (1952, January 7). *Pauline Beery Mack*. Testimonial presented at the luncheon of Nu Chapter of Sigma Delta Epsilon.

Williams, I. R. (1952, October 1). *Letter to Department of Public Relations, Texas State College for Women*. [The Women's Collection, Texas Woman's University, Denton, Texas]

Winning, F. G., & Mack, P. B. (1930). Silk dress study I: Style, workmanship, size, and fit of garments in relation to price. In P. B. Mack, Students in Textiles and Textile Chemistry The Pennsylvania State College, F. G. Winning, S. Stark, & E. R. Gray, *Resume of an eight-year series of consumer studies on silk and rayon* (n.d., The Pennsylvania State College Bulletin, Home Economics Research Series Publication Number 3, pp. 3-14). [The Women's Collection, Texas Woman's University, Denton, Texas]

Women leaders plan tour of U.S. Army missile sites. (1960, September 16). *The Dallas Morning News*. Retrieved August 11, 2008, from http://infoweb.newsbank.com

Women's college to give three honorary degrees. (1952, June 3). *Allentown Call*. [Pennsylvania State University Archives, ABVF Mack, P. B.]

Woodby, E. (1962, March 11). Early American treasure: Dr. Mack's home displays items from everywhere. *The Denton Record-Chronicle*, p. 6. [The Women's Collection, Texas Woman's University, Denton, Texas]

Yarmey, K. A. (2006). *Labors & legacies: The chemists of Penn State 1855-1947*. University Park, PA: The Pennsylvania State University Department of Chemistry.

Appendix A

Interview Questions

1. How would you categorize your relationship to Dr. Pauline Beery Mack?
    a. Describe your relationship (duration, frequency, and context).
    b. Was there a power/hierarchical element to this relationship?
    c. If so, was that element a major factor in the relationship? How was it manifested?
2. How would you characterize Dr. Mack's personality and other attributes?
3. If Dr. Mack was your instructor, how would you describe her method of teaching?
    a. How did you/her students react to her teaching methodology?
    b. Did you observe or come to know in some other way the perception of Dr. Mack's supervisor(s) regarding her teaching methodology?
    c. In what ways did Dr. Mack's teaching methodology mesh or not mesh with your (and others) learning needs/style?
    d. Did Dr. Mack's teaching influence any educational and/or career decisions that you or others made? If so, describe the context.
    e. Describe any events that stand out in your mind.
4. If Dr. Mack was not one of your instructors, were there any instances in which you learned from her in another context?
    a. What was the nature of this context?
    b. What behaviors and attributes did Dr. Mack exhibit in this context?
5. Were you involved in or did Dr. Mack share with you any career or educational decision that she was faced with or dealt with?

a. How did Dr. Mack handle this situation and decision?
b. Who, if any, were the individuals who played a role in the decision and what was that role?

6. Were there any problems or barriers/obstacles handled by Dr. Mack that stand out in your memory?
    a. How did Dr. Mack react to the problem(s)?
    b. What process did she utilize to deal with the problem(s)?
    c. Did Dr. Mack arrive at a solution to the problem(s)? How would you categorize that solution?
7. Were there any turning points in Dr. Mack's life?
    a. What was the context?
    b. What was the outcome?
8. How did Dr. Mack interact with you and others?
9. How would you describe Dr. Mack's personal relationships? Professional relationships?
    a. What influences, events, or childhood relationships took place during Dr. Mack's formative years?
    b. Were there individuals who played key roles in her life? If so, what was the nature of the relationship(s) and role(s)?
    c. Did Dr. Mack have any mentors? Describe the relationship(s).
    d. Did Dr. Mack mentor you or others you know? Describe the relationship(s).
    e. How did Dr. Mack balance her personal and professional lives?

10. What were your perceptions regarding Dr. Mack's work?
    a. How did Dr. Mack perceive her work?
    b. What type(s) of goal(s) was Dr. Mack attempting to achieve?
    c. Why did Dr. Mack value that goal or goals?
    d. Did Dr. Mack have any qualities, attributes, or beliefs that either hindered or contributed to her achieving her work goals?
    e. Was there anything that made it difficult for her to accomplish her goals? Workplace constraints?
    f. What perceptions did others have regarding Dr. Mack's work?
    g. Did Dr. Mack feel responsibility and/or loyalty to anyone or anything in her work?
    h. Are there any specific instances that you recall regarding any reactions to Dr. Mack's work? What was the nature of those reactions?
11. Dr. Mack was both an educator and a scientist. How did these dual roles suit the Dr. Mack that you knew?
    a. What do you think attracted her to these fields?
    b. Did Dr. Mack express opinions or thoughts regarding her selected careers or regarding any alternate career paths she might have chosen?
12. As we near the end of our interview, is there anything we didn't discuss that you would like to add?
13. May I contact you in the future for clarification and follow-up?

Appendix B

Alignment of Research and Interview Questions

Research Question	Applicable Interview Questions
1. What factors contributed to Dr. Mack's educational and career decisions to engage and persevere in the dual professions of teaching and science?	Questions 2, 3, 4, 5, 6, 7, 9, 10, 11
2. What patterns or connections to the theoretical frameworks of constructivism, creativity, and leadership are evidenced by the traits and behaviors displayed by Dr. Mack?	Questions 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
3. What transforming moments or epiphanies are evidenced?	Questions 5, 6, 7, 9
4. What, if any, educational, career, and life challenges did Dr. Mack experience that pertained to stereotyping, gender, bias, or other issues revealed by this study? a. How did Dr. Mack address identified challenges and in what ways did they influence her decisions? b. Were there mediating factors that supported successful handling of challenges?	Questions 5, 6, 7, 9, 10, 11
5. How did the field perceive and recognize Dr. Mack? Is there evidence in retrospect to corroborate or refute the perceptions of her time?	Questions 3, 10

Appendix C

Attribute Categories- Second Iteration of Coding Author Interviews

Confidence	Control	Change Agency	Intellect
Not bothered by perspectives of others; self-confident; strong personality; popular speaker; a presence; status of her own; walked with a stature; decisive; intimidating; would tackle anybody; outgoing; knew her goals and strove to get them; wasn't afraid of anyone; outgoing	Controlling; strong personality; wanted things done her way; determined; intrusive; particular; intimidating; decisive; struggled to keep working at end; manipulative; in charge; took command	Change agent; engaged others; up-to-date and enthused about new things; delivered; didn't rest on her laurels; crossed boundaries to get things done; networker; changed perspective on what women could do; changed perspective of bone; changed TWU's graduate program	Respected skills of others; brilliant; recognized when women weren't; skilled in recognizing talents of others; knowledgeable; visionary; up-to-date; such an intelligent woman

Nonconformance	Humor	Generosity	Persuasiveness
Attire; inattentive to appearance; picnic-basket briefcase; not bothered by others' perspectives; wanted it done her way; unique; unusual; gender-free perspective; colorful language; finger calculator; eccentric; uninhibited; crossed boundaries; flamboyant	Enjoyed jokes; uninhibited; enjoyed parties; humorous; fun to listen to, entertaining as a teacher	Generous; gave funds to causes and students; took students to lunch; helped staff members; always there when you needed her; held baby shower and weddings at her home; flowers for sick students and secretaries	Could charm anyone she chose to charm; persuasive; engaged others; gifted at being in touch with people; networker-found ways to contact others; could get people to do things they didn't want to do; able to motivate people; raised money

Attribute Categories- Second Iteration of Coding Author Interviews, Continued

Networking	Communication	Expectations	Creativity
Could charm anyone she chose to charm; could tailor to audience; skilled in recognizing talents of others; engaged others; gifted at being in touch with people; got people to do things beyond the job; networker- found ways to contact others; scrounged to get research money	Could charm anyone she chose to charm; popular speaker, could tailor to audience; persuasive; engaged others; able to talk to people re their interests and their levels; gifted at being in touch with people; outgoing; networker; humorous	Expected others to work holidays; work on Saturdays; intrusive on private life; particular, wanted quality things; high standards/ expectations; very demanding, high expectations during her students' doctoral or theses work; hard taskmaster; had staff do things beyond job	Change agent; creative; visionary; enthused about new things; invented method to monitor changes in bone; recognized potential of entirely different way for human physiology to function

Persistence	Vision	Stringency	Productivity	Ambition
Persistent; determined; driven to get things done; delivered; didn't rest on her laurels; knew her goals and strove to get them; overcame interference with her doctoral research; battled to get what she wanted; if couldn’t get funding from Guinn, persuaded others; would tackle anyone and not let up; hassled to get PA files	Change agent; visionary; up-to-date and enthused about new things	Wanted things done her way; difficult; expected others to work holidays and Saturdays; intrusive on private life; particular; very demanding, high expectations during students' doctoral or theses work; hard taskmaster; wanted it done quickly	Productive; driven to get things done; didn't rest on her laurels	Driven to accomplish things; knew her goals and strove to get them; scrounged to get research money; ambitious; driving force her own ambition; strong in her ambitions to get things done

Attribute Categories- Second Iteration of Coding Author Interviews, Continued

Teaching	Influence	Barriers/Obstacles	Advocacy/Support
Learned from just being with her	Able to raise funds	Interference with her doctoral research	Supported students and staff financially; took students to lunch; gave unpaid maternity leave; held weddings and baby shower at her home;
Very demanding- high expectations during students' doctoral or theses work	Kept aura of being tough, unapproachable, mystique to influence others	Being female perceived as an impediment- had to battle to get what she wanted; rare to have a female with her power at TWU	Always there when needed; went far beyond second mile for her students; encouraged George Vose to get his degree
Flamboyant; fun, humorous; varied her methodologies	Changed perspectives of others	Prevented from fully carrying out her NASA research- women not allowed on board the carriers	Believed her job was to help people move on with their lives
Good rapport with students; role model for students	Able to influence the influential- legislators, wealthy individuals; could get what she wanted from Guinn		Committed to equal rights, African American students; assisted Chinese students
Committed to her work with grad students	Inspired others; role model for students		Took her parents into her home before they died

Attribute Categories- Second Iteration of Coding Author Interviews, Continued

Relationships
Students- entertained; supported financially; polarized viewpoints; respected by; demonstrated caring; special rapport with some; reciprocal- would do anything for students and they would do for her; established traditions; demonstrated interest in and concern for **Employees/ Colleagues**- some bitter feelings at PSU; polarized viewpoints; respected by; not always loved; demonstrated caring; special rapport with some; people paid homage; entertained; most didn't say no to her; easy to work with/for; crossed boundaries; edginess on her part at times; jealousy on part of colleagues; good to them **Parents**- reciprocal love; strong reciprocal support; reciprocal devotion **Spouse**- reciprocal love and devotion; respect; commitment; no interest in anyone else; devastated by death; active in church and social things when he was alive **Friends**- Cared greatly for George Vose, one of her best friends; good friends with LaRue and Mary Willard. Part friend, part boss to Jean Sherrill

Appendix D

Attribute Categories- Second Iteration of Coding Interviews Conducted by Others

Confidence	Control	Change Agency	Intellect
Believed she was right; outgoing, no shyness; couldn't intimidate her; popular speaker	Hands-on; took credit; knew how she wanted things done; felt threatened at end that she would be replaced; controlling; tried to be in control; respected independence; delegating not her strong suit; manipulative; pretty good conniver; enjoyed intimidating you; domineering, would interfere in your private life if could, wanted to direct everyone; had a weapon for every occasion; people deferred to her, did it her way	Change agent; always managed to get into the new field, develop that and the program on campus; helped with TWU identity; wanted to change name at TWU from Home Economics because name might limit type of funding she wanted; networker; changed perspectives	Brilliant; so brilliant not normal; honest genius; knew how to get things done even if she didn't know how to do them; knew how to come up with results; had so much talent and ability; knowledgeable; lifelong learner; read current events; capable; complex; good in math; enjoyed scholarly things

Attribute Categories- Second Iteration of Coding Interviews Conducted by Others, Continued

Nonconformance	Humor	Generosity	Persuasiveness
Colorful language; not domestic- did not take care of her own food, clothing, and shelter; didn't care what others thought about her; didn't attend to her dress and looks; nice to children but viewed them as a burden; atypical; unorthodox; rules were made to be broken, found a way around them; had her own way of doing things; idiosyncratic; bad driver; finger calculator; couldn't be frilly girl her mother wanted; unique; never met anyone like her, most unforgettable character; very masculine; talked to dogs on phone long distance; liked males better than females	Hilarious; funny; told wonderful jokes, loved to hear them, even dirty ones; liked to have fun; loved parties and celebration	Generous, sent flowers and gifts; remembered courtesies; gave students money, never had any left; money meant nothing to her; if she was on your side, would go all out, spend any amount of money and work just hours; compassionate- helped employees in financial trouble; would check on pregnant employees every day or so; took students to lunch; held baby shower at her home	Convincing; adapted behaviors to situation; chameleon; powerful charisma; innate ability to find what would motivate people; knew what would appeal to general public, could generate interest; sales ability; could talk a good game; was a salesman, put the icing on the cake; persuasive; she got the job, was good at that; could make you do what she wanted, con you into wanting to do it, that's how so much got done; could sway an audience, the Legislature, or anybody she needed to talk to; good at convincing others when an extension was needed; could lay on flattery and convince you to do your best for her; never lost in defending her methodology in Washington

Attribute Categories- Second Iteration of Coding Interviews Conducted by Others, Continued

Networking	Communication	Expectations	Creativity
Went out to others; understood the community and importance of support from others; attended events on campus; loved parties and celebrations; cognizant of the need for interactions- held events; networker; outgoing; lots of travel to secure funds; collaborated with lots of individuals	Demonstrated anger; had social graces; ability to carry on conversations with all types of people; popular speaker; outspoken; remembered courtesies; liked a good battle- you could cross her but better be right- would congratulate you; could sway anyone; humorous	Knew how she wanted things done; liked nice things; expected employees to work hard; worked them 12 hours a day for 3 months; expected employees to work holidays; demanded excellence; exasperated if felt not giving your all	Innovative; would jump at things, always managed to get into the new field, develop that and the program on campus; pioneer in studies

Persistence	Vision	Stringency	Productivity	Ambition
Did not want to end career, wanted to be brought to work in wheelchair; fought to the end to not have to leave; fought for raises for her staff; traveled to secure funds; could do anything she set out to and get it done one way or another; knew what she wanted- the final goal and had the people. If she couldn't do it, had someone who could; achieved what she wanted	Leader in field; foresight; pioneer in studies; believed we needed to improve nutrition as a civilization; wanted to change name at TWU from Home Economics because name might limit type of funding she wanted	Hurt feelings of others; outspoken, made enemies; self-centered; slave driver; expected employees to work hard; worked them 12 hours a day for 3 months; expected employees to work holidays; demanded excellence; harder to work for at times- deadlines; exasperated if felt not giving your all; could blow up; could demand attention; demanding; if you crossed her, you got the results of it	Hard-working; could make you do what she wanted, con you into wanting to do it, that's how so much got done; write for hours; achieved what she wanted	Her work was her life; buried in her work; had world's record as far as reputation went; famous in her own right; knew what she wanted- the final goal and had the people. If she couldn't do it, had someone who could; achieved what she wanted; wanted to be recognized

Attribute Categories- Second Iteration of Coding Interviews Conducted by Others, Continued

Teaching	Influence	Barriers/ Obstacles	Advocacy/Support
Knowledgeable; lifelong learner-current; provided opportunities for interaction-social events; learned from her files and asking her questions; credited by students for their successes; privilege to study with	Changed perspectives; brought recognition; innate ability to motivate; had clout; sales ability; Could influence the influential-Legislature, Guinn, or anyone; utilized flattery; helped with TWU identity; effectively defended her methodologies; effective at getting jobs	Perceived that Home Economics name at TWU could limit funding opportunities; Prevented from fully carrying out her NASA research- women not allowed on board carriers; constantly bombarded by people that didn't believe in their work and how good she and they were; had to defend her work 3 times in Washington	Took students to lunch; had social events for students; had recognition ceremonies for outstanding students; did things to help students be aware of the importance of education and of their importance as people; sent flowers to students and staff; fought for raises for her staff; allowed employee to take classes; provided time off for illness, vacation; supported students and staff financially; helped students academically; concerned with education and improvement of women; had policy to get current degree people out of house and then worry about next batch- they all had to help each other; demonstrated pride in her students; acknowledged by students as contributing to their successes; crossed boundaries to intervene on behalf of others

Attribute Categories- Second Iteration of Coding Interviews Conducted by Others, Continued

Relationships
Students- supported financially; provided opportunities for interaction- social events; highly respected for her knowledge and ability; polarized viewpoints; endearing generosity; revered her after completing dissertations/theses; conflict with some; needed someone to provide security and companionship; subordinate status- lack of intimacy **Employees/ Colleagues-** conflict between her and existing TSCW faculty; highly respected for her knowledge and ability; not discrete in showing displeasure; rapport with Guinn; people deferred to her, did it her way; endearing generosity; demonstrated caring and concern; many long-term employees grew to love her and would do anything she asked; broken trust with a few; feared by some faculty; laughed at by some; envied for her mind; employees rallied and did what needed to be done whenever she was sick; greatly missed for a long time; engendered mixed emotions; highly thought of in her field but lots of jealousy over her accomplishments **Parents-** NA **Spouse-** wanted her to have good relationships in Texas; adored and revered him; handicapped without him; insecure without him; light went out, no flicker- Texas not her happiest time; devastated by his death **Friends-** George Vose **Community**- valued by; respected and honored by people of Denton

Appendix E
Attribute Categories- Second Iteration of Document Data Coding

Confidence	Control	Change Agency	Intellect
Took on developing a chemistry program for women at PSU; Adamant about health hazard of lead weighting in spite of research to the contrary; Not deterred by others initially scoffing at bone research; Student thought her appearance of capability was one of the keynotes to her personality and character; Took on the challenges of building a research program at TSCW; Not afraid of anything	Wanted her issues of *The Chemistry Leaflet* bound uniformly; Research projects in chemistry and textiles consolidated under Ellen H. Richards Institute with Pauline as director; in charge of weather, too	Petitioner with others to form ACS division; Developed chemistry program for women at PSU; Instituted study of Textile Chemistry at PSU and built it into a field for graduate work; Changed the lay descriptive perspective of bone; So many industrial grants and projects that PSU consolidated them under one umbrella- Ellen H. Richards Institute; Courted by President Guinn of TSCW to bring about major change at University-created new College of Household Arts and Sciences and doctoral research program; Instrumental in recasting TWU's identity to that of a premier research institution	Precocious child; talked early; early memories; at top of her public school classes; Authored textbooks & book for general public; Invented methodology for and pioneered use of X-rays to monitor changes in bones of living subjects; Inquiring mind; probing, productive mind; Referred to as brilliant dean; Excellent mind; Still an intellectual giant though slightly stooped by the years (1972); One of those people who had to know; Leadership for the advancement of knowledge; Equal parts brains, style, and chutzpah

Attribute Categories- Second Iteration of Document Data Coding, Continued

Nonconformance	Humor	Generosity	Persuasiveness
One of only 2 women on chemistry faculty when came to PSU; Kept one of the monkeys for NASA research at her home; Lack of pretense; Attire; Held birthday parties for dogs; marital role	Known as amusing teacher at PSU; Lauded as an inspiring teacher with a keen sense of humor	Used own funds to purchase research equipment; Not influenced by money; poured a substantial portion of PSU salary back into her work; Donated prize money for artists to the Society of American Graphic Artists; Donated her honorarium from Piper Professor award to Research Foundation at TWU; Donated land to Denton for parks; Left most of her estate to former student who was her live-in companion; also left a bequest to TWU for research	Convinced her mother to give her 2nd chance at college; Persuaded parents to move to State College; Highly successful in raising funds from diverse sources, PA & Texas; Convinced PA Dept. of Health to allow her to take nutrition files from PSU to TSCW; Obtained NASA contracts for research; Could charm or scare the hair off a jackrabbit

Attribute Categories- Second Iteration of Document Data Coding, Continued

Networking	Communication	Expectations	Creativity
Collaborated with others on publications; Petitioner with others to form ACS division; Diverse group of supporters for Student Science Clubs of America and other projects; Collaborated with PA Dept. of Health; large number of medical personnel and researchers; Collaborated with researchers from other institutions; Obtained funds from diverse sources; Massive 25th Wedding Anniversary celebration involved diverse organizations and elaborate preparations; paralleled professional undertakings- grand scale accomplishment not an individual endeavor; Capable organizer	Effusive; Moderated broadcasts; Authored book for general public- entertaining and readable style; Presented to diverse audiences, in demand as a speaker; masterful presenter; Prolific scholarly publications; Reached public through newspapers and popular magazines; Dictated responses to 25,000 of the letters sent to *Reader's Digest*; Articulate; Low, deliberate speech (TWU, 1960s) & animated, glowing dark eyes; Frank and fearless speech that never failed to impress her audience; Her way of talking to men overwhelmed them- knew how to do it	Spent considerable time and money preparing for a career and had no interest in domestic pursuits; Expected much of students and employees and gave much in return; Extensions of students' studies; always went first class	Outlined new household chemistry courses at PSU, wrote a textbook and lab manual; Founded *The Chemistry Leaflet*; Instituted study of Textile Chemistry at PSU and built it into a field for graduate work; Charted new territory with the type and scale of her data collection for the PA Mass Nutrition Studies; Invented the methodology and pioneered the use of X-rays to monitor changes in the bones of living subjects- received the Garvan Medal in part for this; Build an inexpensive home evaporator with her husband as part of effort to improve civilian nutrition during time of war; Nutritional study of college girls at TSCW- girls told their story on color film geared to the interests of teenagers; Found solution to skirting mandatory retirement age at TWU; NASA bed rest studies

Attribute Categories- Second Iteration of Document Data Coding, Continued

Persistence	Vision	Stringency
Brought her Latin grade up to par; Created chemistry program at PSU in face of opposition and without Pond's support; Tenacious in pursuit of development of industry standards to guide consumers; Spent own funds on equipment to enable research; Bestowed with faculties, determination, and physical endurance to overcome discouragement and forge on to success (Garvan Medal); Hassled PA Dept. of Health for permission to take nutritional files from PSU to TSCW; Found way to skirt mandatory retirement age at TWU to continue working; One of those people who had to know	Brought Pond's plan to fruition without him; Saw the potential of scientific research and the necessity for conserving raw materials. Realized that quest for materials more thoroughly connected to quest for energy than previously thought; Instituted study of Textile Chemistry at PSU and built it into a field for graduate work; Charted new territory with the type and scale of her data collection for the PA Mass Nutrition Studies; Quantified the ideal school lunch; nutritional studies had cradle to grave implications; Invented the methodology and pioneered the use of X-rays to monitor changes in the bones of living subjects; Foresight to connect nutrition and bone density research at TWU with issues of calcium loss during manned space flights; One of the all-time greats in her field-leadership for the advancement of knowledge	Real go-getter who often called researchers into the lab in the wee morning hours

Attribute Categories, Second Iteration of Document Data Coding, Continued

Productivity
Missouri State- student assistant in physiology lab; Demanding teaching schedule at PSU + independent research + tutored on own time; Work involved in *The Chemistry Leaflet*; Advocated for improvement of children's nutritional well being through multiple media and forums; Wrote textbook and book for general public; Consummate purveyor of information for general public; Instituted the study of Textile Chemistry at PSU and built it into a field for graduate work; Prolific publications; Prolific accomplishments as a systematic researcher and thorough investigator, as a versatile editor, a capable organizer, and enthusiastic administrator; Presented to diverse audiences; Charted new territory with the type and scale of her data collection for the PA Mass Nutrition Studies; Implications from cradle to grave- continued this pattern in Texas; So many industrial grants and projects that PSU consolidated them under one umbrella- Ellen H. Richards Institute; Dictated responses to 25,000 of the letters sent to *Reader's Digest;* During transition year, worked in PA and Texas; Instrumental in establishing doctoral research program at TSCW; referred to as energetic dean, TWU- efforts knew no boundaries; PI on NASA studies in her 70s; Probing, productive mind; Worked very long hours; Continued to publish articles and give presentations in her late 70s; Endless worker

Attribute Categories, Second Iteration of Document Data Coding, Continued

Ambition
Postponed marrying for 4 years so as to not interfere with her professional work; Joined national committees; served as national chairman; Became nationally known latter half of 1920s for research on synthetic textiles and later regarded as international expert on Textile Chemistry; Drew attention to Penn State's research in support of consumers and industry; Undertook massive scale research project in PA Mass Studies in Human Nutrition; research had cradle to grave implications; So many industrial grants and projects that PSU consolidated them under one umbrella-Ellen H. Richards Institute; hoped it would interest people of all socioeconomic levels across the country and be worthy of the name; Tackled creating a doctoral research program at TSCW; National spotlight on her work continued after move to Texas; Efforts at TWU grew enrollment; Pursued involvement with NASA research; Dedicated to proving that TSU was more than a girls' finishing school

Attribute Categories, Second Iteration of Document Data Coding, Continued

Teaching
Norborne HS- physically put an end to discipline problems; Webb City HS- coached girls' basketball team and reluctantly conducted orchestra; Demanding teaching schedule and independent research studies at PSU- still managed to tutor students on her own time declining compensation; Student perspective- amusing & spirited, known for entertaining lectures at PSU; down-to-earth; humanness; no instance in which she wouldn't enjoy herself or find something worthwhile; flamboyant; Class of 1923 voted her their most inspiring teacher; Dynamic teacher, colorful and entertaining; Lauded as an inspiring teacher with a keen sense of humor; Dean Wendt- thought she was superficial, showed students lots of pictures and did anything to interest and amuse them; called her course a disgrace; *The Chemistry Leaflet* focused on relevancy, included review of prior topics; Suggested problems for study and provided assistance throughout the work; expended own funds on needed equipment; Students under her guidance conducted and published many diverse studies; Received Garvan Medal in part for her work in directing graduate students in their research; Some of her students at PSU thought her classes were so enjoyable and helpful that they were worthy of an admission fee; Student thought her appearance of capability was one of the keynotes to her personality and character; Known as excellent teacher with zeal for research; Gave special help to students- patient assistance to students who were slow and urging the bright to greater efforts; Denton home contained many gifts from former students; Frequently worked with grad students at her Denton home, providing space for them to leave their work spread out; Some students followed her to Texas to complete their studies; Loved teaching and her subject, with her energy and charm this made her a dynamic presence in the classroom

Attribute Categories, Second Iteration of Document Data Coding, Continued

Influence	Barriers/Obstacles
Opinion sought on love interest of fellow teacher; Garnered support and assistance for *The Chemistry Leaflet*; garnered support for Student Science Clubs of America; Effectively involved children and students in presentations to garner support, PA & Texas; Effectively garnered funds from diverse organizations to support research; Magnitude of grants and projects prompted Penn State to consolidate them under the Ellen H. Richards Institute with Pauline as director; Mentioning association with Pauline opened door to interview with A. J. Carlson for Harry B. Henderson; Guinn declared her appointment as a landmark in the history of Texas education and in the industrial development of Texas; Some students and staff followed her to Texas; Served as inspiration to others after her death; Her way of talking to men overwhelmed them- knew how to do it	Conflict with female Missouri State Latin department head [engaged support of male chemistry department head]; Male principal at Webb City did not give her a raise- perceived she didn't need it [found another job]; After graduating, wanted to go into pure chemical research, but found it was a man's field [turned to the application of chemistry to medical, household, & industrial problems]; Frequent opposition as she created PSU program after Pond's death [persevered]; Successor to Dr. Honeywell expended great energy and ingenuity in discouraging her from her doctoral studies; more than one individual interfered with her research by turning lights on [found sympathy and help from another department, Dr. David Duncan; help from Ernest Axman & Warren Mack; manuscript help from her mother]; Some male colleagues continued to call her Mrs. Mack after she earned her doctorate; Garvan Medal that she received was compensatory in nature- not until 1967 did a woman win any other ACS prize; Decided to spend the remainder of her productive years in a more conducive environment as regards space and the absence of internal competition (move from PSU to TSCW); Not on original list of colleges and universities to be considered for NASA calcium loss studies- girls' finishing school? [obtained the opportunity to submit proposals and sold TWU's program of measuring calcium density through X-rays]; Missed out on a key experience related to NASA studies- women not allowed on board carriers

Attribute Categories, Second Iteration of Document Data Coding, Continued

Advocacy/Support
Tutored students, declining fees, on own time;
Founded *The Chemistry Leaflet* and supported it with own funds to explain science and inspire scientific attitude among youth; quotes from Jane Marcet intended to reach females; dedicated to attracting more students to chemistry;
Guided development of Student Science Clubs of America;
Participated on committee directing the organization of study groups in women's clubs to facilitate greater understanding of chemistry among women;
Adamant about health hazard presented by lead weighting; represented American silk consumer, advocated for industry standards; Consumer advocate regarding price and quality; advocated for the best possible service to the public to promote customer satisfaction;
Suggested problems for study, extended scope of studies, and provided assistance throughout the work; purchased equipment with own funds to support research;
Concerned with the physical ramifications of poor nutrition in children with low SES status- brought public attention to the issue; advocated for better education on nutritional needs in pregnancy; advocated for school lunch program as way to meet nutritional needs of children; worked with others to support improved nutrition of civilians in time of war; advocated for special attention to diets of children with disabilities;
Consummate purveyor of information for the general public;
Served as national president of Iota Sigma Pi, women's chemical honorary;
Organized both social and professional fraternities for women;
Instrumental in establishing doctoral research program at TSCW;
Worked with grad students at her Denton home, providing space for them to leave their work spread out;
Throughout her career, supported research with her own funds;
Dedicated to proving that TSU was more than a girls' finishing school;
Avocation for helping young career-minded women obtain an education- had her own women's liberation program for energetic and intelligent young women with promise (PSU); real understanding and true belief that women should be able to excel in careers as men did

Attribute Categories, Second Iteration of Document Data Coding, Continued

Relationships
Students- developed tradition of graduate students wearing her wedding veil; crossed boundaries, complex
Employees/ Colleagues- found dissertation support from Dr. David Duncan & Ernest Axman; employee relationships crossed boundaries, complex
Parents- mother a strict disciplinarian- work before play; mother expected highest school performance; mother accompanied her to college; mother helped with dissertation manuscript and research reports; mother ran the Old Main Art Shop until her retirement; Father helped at store and with clerical work for *The Chemistry Leaflet*. Mother helped with social aspects of Pauline's work
Spouse- Warren contributed his artwork to Pauline's publications; Pauline professionally oriented, Warren accepted her on her terms; similar interests & some career intersections; contrasting personalities; never had children; supported dissertation studies; collaborated on publications; collaborated to support improved nutrition of civilians in time of war; massive 25th wedding celebration; Pauline cognizant that her husband's liberal-mindedness about her work supported her work ethic and success; devastated by his untimely death; Denton home contained family heirlooms and grand piano Warren had given her; his engravings were hung on the walls in her Texas office; nostalgic over fall colors they had enjoyed together
Friends- good friends with Mary Willard; considered G. G. Pond a friend & leader
Community- editorial in CDT spoke of the deep sense of loss regarding Pauline's decision to go to Texas- so closely connected with Penn State's progress that few thought she would ever leave; Denton community valued her- Otis L. Fowler Award
Professors and Employers- conflict with female Latin department head; rapport with male chemistry department head; considered G. G. Pond a friend and leader; encouragement and support from Dr. Frank Whitmore, head of PSU Department of Chemistry

Appendix F

Chronology of Events in the Life of Dr. Pauline Beery Mack

Date	Event	Category
December 19, 1891	Born in Norborne, MO	Life Event
	Took music lessons as child- promising singer	Talent
~1908-1909	Norborne HS basketball forward- team ranked first in state	Talent
1910-1913	Missouri State University- A.B. degree- Chemistry major	Education
1913-1918	MO: High school science teacher- Norborne HS; Head of science departments- Webb City HS & Springfield HS	Career
1919	Columbia University- Master of Arts	Education
1919	Went to Penn State at invitation of George Gilbert Pond	Career
1919-1952	Staff member, Dept. of Chemistry, PSU	Career
October 1919	Met Warren Mack	Relationship
April 11, 1920	Confirmation- St. Andrew's Episcopal Church, State College	Life Event
May 1920	George Gilbert Pond dies unexpectedly	Loss
December 27, 1923	Married Warren Mack	Life Event
1923	Published textbook and laboratory manual- *Chemistry Applied to Home and Community*	Publications
1924	Pauline and Warren open the Old Main Art Shop in State College	Avocation

Date	Event	Category
1925	Pauline's parents relocate to State College	First Degree Relationship
Latter half of 1920s	Became nationally known for research on synthetic textiles	Prominence
1927	Founded *The Chemistry Leaflet*	Advocacy
1927 & 1928	Elected to serve as national chairman of the textile section of the American Home Economics Association	Leadership
1929	Began doctoral research 10 years after coming to PSU	Education
1930	Published *Stuff, The Story of Materials in the Service of Man*	Publications
1932	Ph.D., Biological Chemistry Major, PSU	Education
1933	Class of 1923 voted Pauline their most inspiring teacher	Recognition
1934-1952	Pennsylvania Mass Nutrition Studies	Research
1938	Elected to Faraday Society of England	Prominence
1940	First Marie Curie Lecturer, PSU	Prominence
January 25, 1941	Ellen H. Richards Institute established at PSU	Leadership, Organizational Milestone
1941-1952	Director, Ellen H. Richards Institute, PSU	Leadership
1944	Death of John Beery, Pauline's father	Loss
1945-1948	National Council President of Iota Sigma Pi	Leadership
December 31, 1946	Death of Dora Woodford Beery, Pauline's mother	Loss

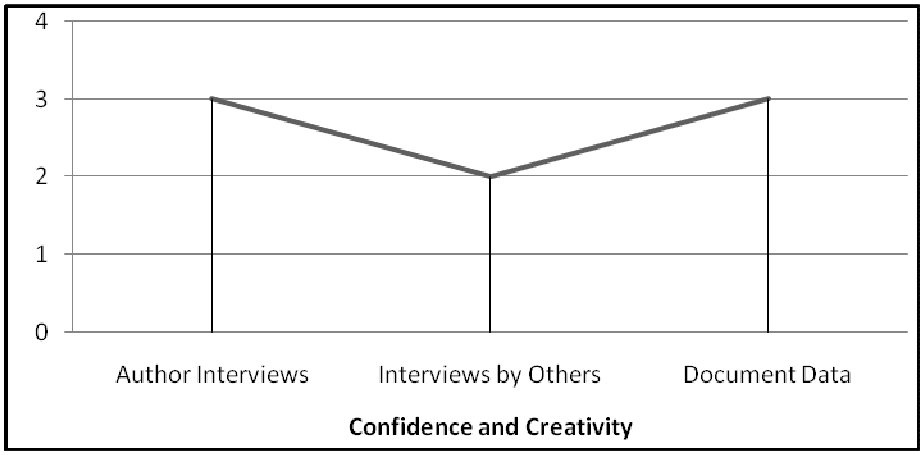
Date	Event	Category
September 9, 1948	Elected to Phi Beta Kappa Associates along with Warren Mack	Recognition
1949	Named as international honorary member of Beta Sigma Phi	Recognition
1949	Distinguished Daughters of Pennsylvania Medal	Recognition
September 8, 1949	Massive celebration of 25th Wedding Anniversary (which was the previous December)	Life Event
April, 1950	Received Garvan Medal	Recognition
May 8, 1951	First female Priestley Lecturer	Prominence
August 16, 1951	Election as Dean of the College of Household Arts and Sciences at TSCW announced by President John Guinn	Career [Major Transition, combined with loss of husband, Turning Point]
1951-1962	Dean, College of Household Arts and Sciences, TWU & Director of Research	Career
September 10, 1951	Lecturer on the Program of the Twelfth International Congress of Pure and Applied Chemistry	Prominence
March 27, 1952	Inauguration of new College of Household Arts and Sciences, TSCW	Leadership, Organizational Milestone
June 2, 1952	TSCW Board of Regents approved creation of doctoral program in the College of Household Arts and Sciences to commence in Sept.	Leadership
June 9, 1952	Received honorary doctor of science from Moravian College for Women	Recognition
June 13, 1952	Penn State Press Release of Warren Mack's retirement, effective August 31	Life Event

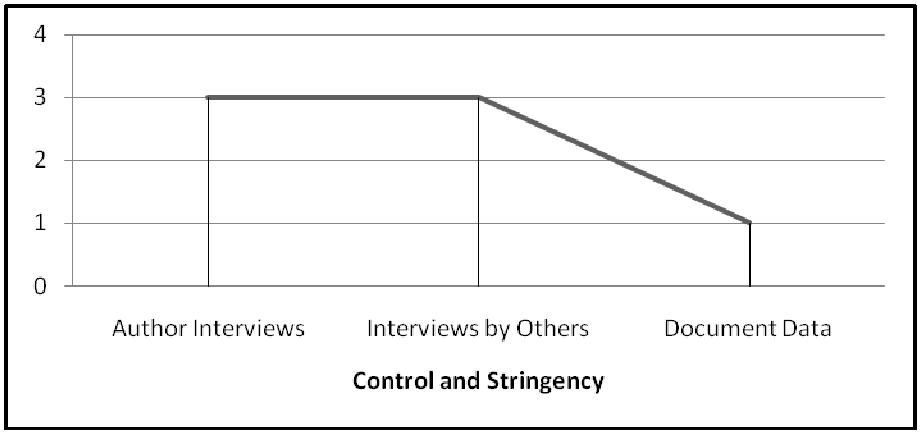
Date	Event	Category
July 6, 1952	Death of Warren Mack, Pauline's husband, from heart attack	Loss [Combined with leaving PSU for TSCW, Major Transition and Turning Point]
August 1, 1952	TSCW Bulletin announced its first college majors leading to doctoral degrees	Organizational Milestone
October 18, 1952	Received honorary doctor of science degree from Western College for Women	Recognition
May, 1953	Became member of Pan-American Medical Association's executive committee, Section of Therapeutics and Nutritional Research	Prominence
June 1, 1953	TSCW conferred first two Ph.D. degrees to students who had begun their work with Pauline at PSU	Organizational Milestone
February, 1958	Elected to membership in Great Britain's Royal Society of Health	Prominence
1959	Named a Piper Professor of 1959	Recognition
December 19, 1961	Turned 70, mandatory retirement age, found way to keep working	Life Event
1962	Retired from deanship at TWU; Remained director of research foundation	Life Event
1962-1970	NASA studies at TWU	Research
1964	Denton Chamber of Commerce Otis L. Fowler Award	Recognition
December 21, 1968	On hand for launching of Apollo 8, age 77	Career
April 23, 1970	First woman to receive Silver Snoopy Award from NASA	Recognition

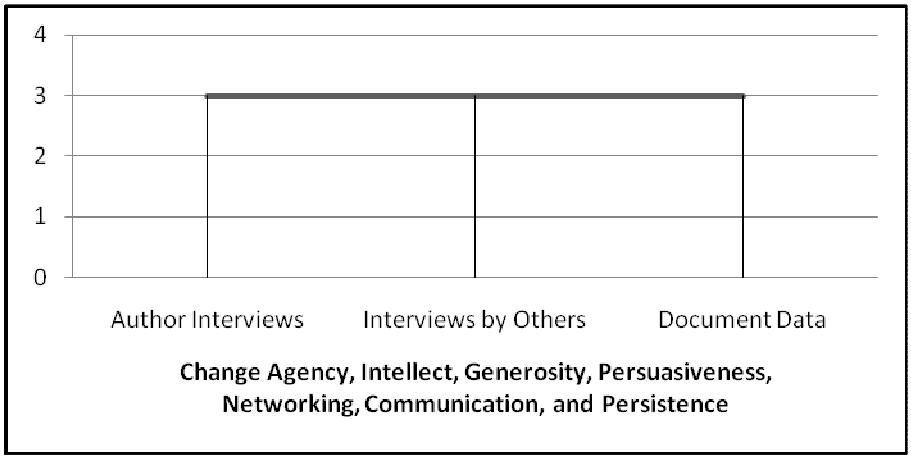
Date	Event	Category
1971	Inclusion in *The 2000 Women of Achievement*	Prominence
May, 1971	Donated land to Denton for public parks	Philanthropy
1973	Retired from directorship of research foundation at TWU at age 82	Life Event
October 22, 1974	Died 2 months before 83rd birthday	Life Event
October 25, 1974	Interred in Centre County Memorial Park next to husband and parents	Life Event

Appendix G

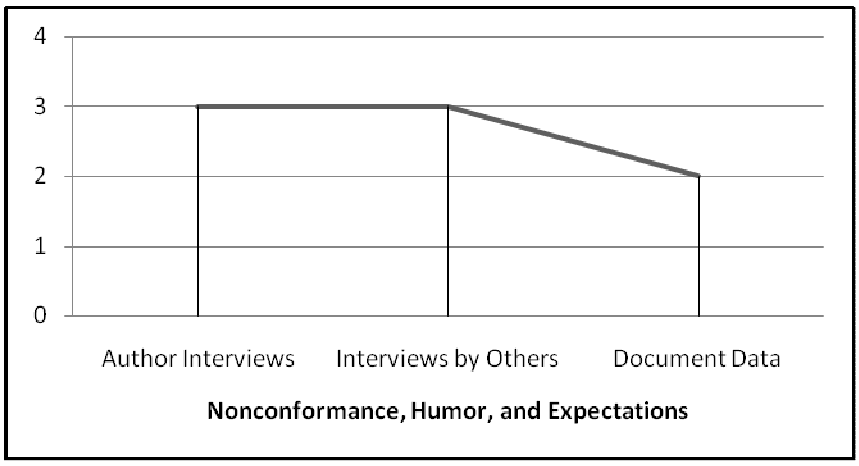
Ladder Diagrams- Pattern Matching

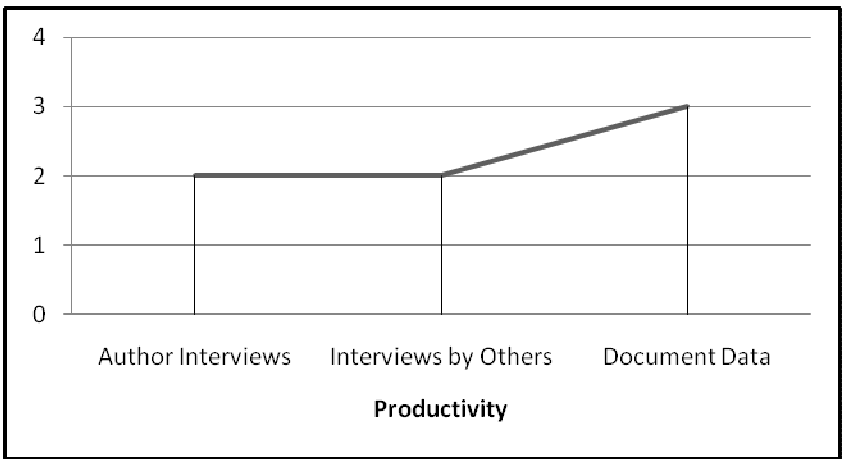


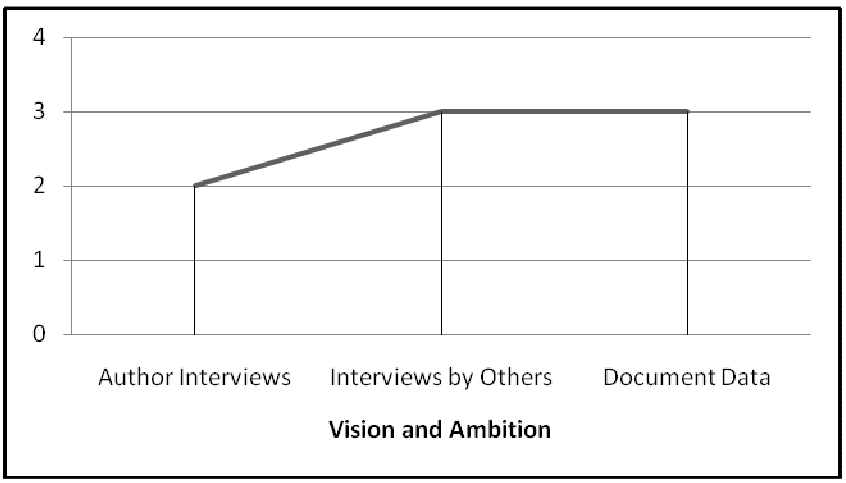




Scale: 1= little evidence; 2= moderate evidence; 3= substantial evidence



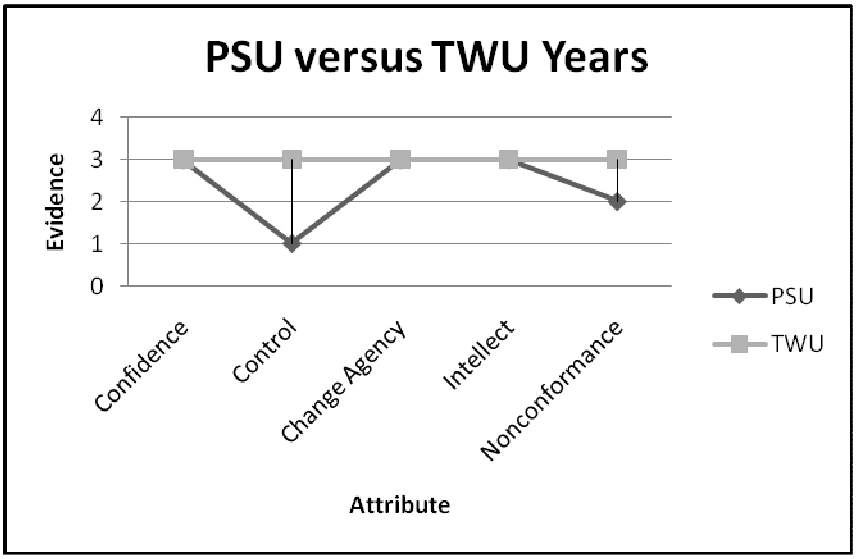


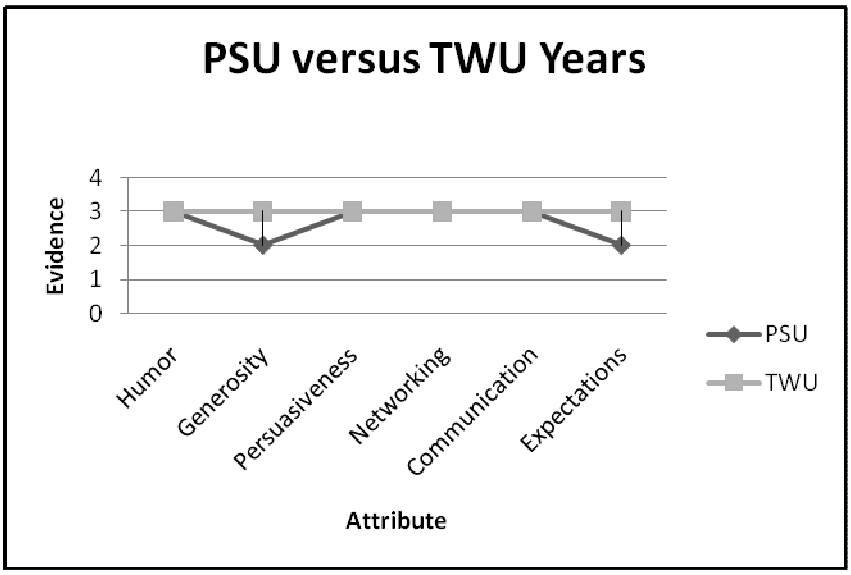


Scale: 1= little evidence; 2= moderate evidence; 3= substantial evidence

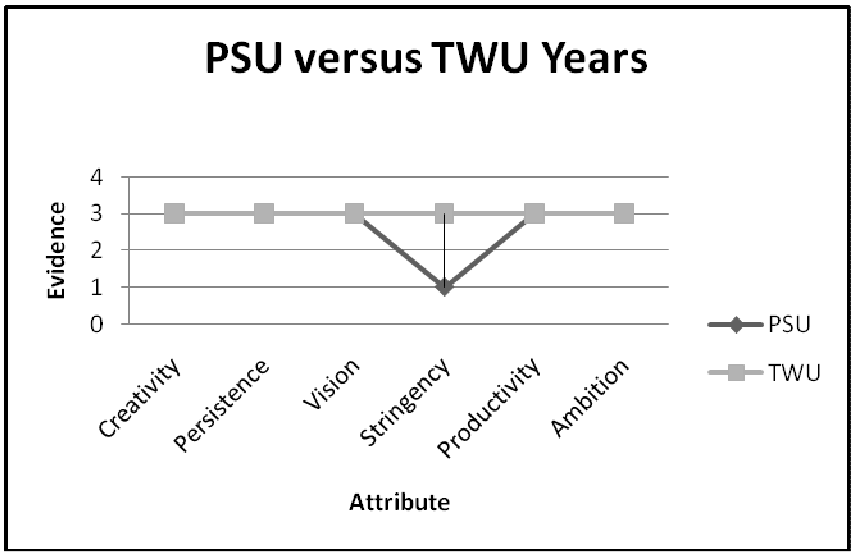
Appendix H

Attribute Comparison- PSU versus TWU Years





Scale: 1= little evidence; 2= moderate evidence; 3= substantial evidence



Scale: 1= little evidence; 2= moderate evidence; 3= substantial evidence