

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Electronic Reference Materials

Libraries at University of Nebraska-Lincoln

August 2008

A culture of technical knowledge: Professionalizing science and engineering education in late-nineteenth century America

Paul Keith Nienkamp

Iowa State University, nienkamp@iastate.edu

Follow this and additional works at: <https://digitalcommons.unl.edu/libelecrefmat>



Part of the [Library and Information Science Commons](#)

Nienkamp, Paul Keith, "A culture of technical knowledge: Professionalizing science and engineering education in late-nineteenth century America" (2008). *Electronic Reference Materials*. 3.

<https://digitalcommons.unl.edu/libelecrefmat/3>

This Article is brought to you for free and open access by the Libraries at University of Nebraska-Lincoln at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Electronic Reference Materials by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

**A culture of technical knowledge: Professionalizing science and engineering
education in late-nineteenth century America**

by

Paul Nienkamp

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: History of Technology and Science

Program of Study Committee:
Amy Bix, Co-major Professor
Alan I Marcus, Co-major Professor
Hamilton Cravens
Christopher Curtis
Charles Dobbs

Iowa State University

Ames, Iowa

2008

Copyright © Paul Nienkamp, 2008. All rights reserved.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iii
ABSTRACT	v
CHAPTER 1. INTRODUCTION – SETTING THE STAGE FOR NINETEENTH CENTURY ENGINEERING EDUCATION	1
CHAPTER 2. EDUCATION AND ENGINEERING IN THE AMERICAN EAST	15
The Rise of Eastern Technical Schools	16
Philosophies of Education	21
Robert Thurston’s System of Engineering Education	36
CHAPTER 3. ADVANCING KNOWLEDGE, TRANSFORMING LIVES – ENGINEERING EDUCATION AT THE MICHIGAN AGRICULTURAL COLLEGE BEFORE 1893	56
CHAPTER 4. <i>NUMEN LUMEN</i> – ENGINEERING EDUCATION AT THE UNIVERSITY OF WISCONSIN BEFORE 1893	111
CHAPTER 5. SCIENCE WITH PRACTICE – ENGINEERING EDUCATION AT THE IOWA AGRICULTURAL COLLEGE BEFORE 1893	161
CHAPTER 6. <i>LITERIS DEDICATA ET OMNIBUS ARTIBUS</i> – ENGINEERING EDUCATION AT THE UNIVERSITY OF NEBRASKA BEFORE 1893	210
CHAPTER 7. ENGINEERING ASCENDENT – ENGINEERING EDUCATION AT MIDWEST LAND-GRANT COLLEGES, 1893 TO 1900	251
The Michigan Agricultural College	254
The University of Wisconsin-Madison	267
The Iowa Agricultural College	281
The University of Nebraska-Lincoln	291
Conclusion	306
BIBLIOGRAPHY	311

ACKNOWLEDGEMENTS

In 1915, the writer Robert Frost penned “The Road Not Taken.” He wrote about two roads, choosing a path, and that the road “less traveled by...has made all the difference.” I began my collegiate journey in mathematics and physics, thinking I would become an engineer. I became a teacher, and learned that I might travel a different path successfully. And now I have concluded this part of my academic studies by writing about a small part of the engineering profession. Often, I felt that I traveled not on a road, but a path of my own making, since no roads seemed to go where I felt I must journey. But along the way I have met mentors and friends who have provided knowledge, guidance, wisdom, and friendship.

First, I need to thank my advisors and my dissertation committee. Alan Marcus provided guidance and mentoring as I began my journey into the history profession and continues to stretch my intellectual curiosity and acumen. Amy Bix stepped in over the last three years as my advisor and mentor as I worked to finish my dissertation. Charles Dobbs provided many months of discussions and suggestions for writing methods that helped me to get through my chapters. Hamilton Cravens has happily offered his years of experience and knowledge during my time at Iowa State, suggesting books, offering encouragement, and always ready to listen to a graduate student with questions. Patrick Barr, though not on the final committee, assisted me with classes, professional guidance, and was a member of my masters and field exam committees. Christopher Curtis provided an outstanding role-model for an aspiring historian, teacher, and colleague. And finally, Robert Kennedy, my advisor at Creighton University, allowed me to enter into the world of the history of science and encouraged me to continue my efforts in this field.

Next, I would like to thank all of the archivists and librarians that have assisted me in my research. Archivists at Iowa State helped me to begin this project five years ago. Archivists and assistants at the University of Nebraska, Michigan State University, and the University of Wisconsin all helped me to find old records, school papers, and made helpful suggestions as to where I might continue my search. I must also thank the

Iowa State University History Department and the Garst Family for their years of financial support. Their assistance made this academic journey possible.

I have made numerous friends that have also made this journey possible, and enjoyable. Jason Chrystal was a mentor, colleague, and friend these many years, providing insights and knowingly telling me what professors were really thinking or saying. T.J. Devine and Jenny Barker-Devine have been friends both in and out of the classroom. And Joe Anderson demonstrated poise, professionalism, good sense, and humor at all times.

I must say a special thank you to Alexandra Kindell. She became a trusted friend and fellow historian. She helped me to think in new ways, she offered saintly patience while reading my seminar papers, listening to my rambling thoughts, and suffering through my stories that always seemed to start in the middle. She helped me to become a better writer, historian, and person. She urged me to try new things, experience the world, and gave me her trust. My deepest thanks and appreciation *mo cara*.

Finally, I must say thank you to my parents and family. I have continued my higher education for many years, and they have unquestioningly offered their love and encouragement as I first wrestled with mathematics and physics and then began to tackle history. My mother and father have graciously supported my academic adventures and shared my excitement and joy as I completed each step. They instilled in me a deep sense of intellectual curiosity and they continue to share their joy of learning with me through all levels of education, historical knowledge, and common sense wisdom. It is often said that the journey is the reward. This has been a long journey with many difficulties, learning experiences, and achievements. Thankfully, I have had wonderful family, friends, and mentors that have made the journey rewarding in so many ways, and allowed me to choose my own paths. Now, this journey is at an end and new journeys await my steps.

ABSTRACT

This manuscript examines the intellectual, cultural, and practical approaches to science and engineering education as a part of the land-grant college movement in the Midwest between the 1850s and early 1900s. These land-grant institutions began and grew within unique frontier societies that simultaneously cherished self-reliance and diligently worked to make themselves part of the larger national experience. College administrators and professors encountered rapidly changing public expectations, regional needs, and employment requirements. They recognized a dire need for technically skilled men and women who could quickly adapt to changes in equipment and processes, and implement advances in scientific knowledge in American homes, fields, and factories. Charged with educating the “industrial classes in the several pursuits and professions in life,” land-grant college supporters and professors sought out the most modern and innovative instructional methods. Combining the humanities, mathematics and sciences, and applied or practical skills that they believed uniquely suited student needs, these pioneering educators formulated new curricula and training programs that advanced both the knowledge and the social standing of America’s agricultural and mechanical working classes.

CHAPTER 1.

INTRODUCTION – SETTING THE STATE FOR NINETEENTH CENTURY ENGINEERING EDUCATION

A Culture of Technical Knowledge examines the interplay of state politics, regional economics, and engineering professionalization at America's first land-grant universities in the upper Midwest and Plains states. Early engineering education in the states of Michigan, Wisconsin, Iowa, and Nebraska depended on a mixture of frontier identity, modernization needs and perceptions, and educational philosophies and emphases. Faculty throughout the country placed increasing emphasis on classroom instruction. But early Midwestern land-grant college faculty in the sciences and mechanic arts asked their students to spend more time developing practical skills in workshops and with real-world experience, than on specialized research. Meanwhile, faculty at Eastern schools focused on developing engineering laboratories in the second half of the nineteenth century in which they could conduct personal research. Midwestern educators continued to incorporate practical training as they adjusted and modified their curricula to meet the demands of the people and the engineering profession, producing a curriculum which combined scientific instruction, practical instruction, and advanced laboratory research.

While a number of historians have investigated various aspects of the history of engineering education, the role of America's early land-grant universities has attracted only limited attention over the last thirty years. Previous studies have primarily emphasized broad institutional growth and the importance of college graduates to localized economic growth and specialized manufacturing. *A Culture of Technical*

Knowledge adds to the existing scholarship by examining the interplay of engineering curricula and practical training with the larger mandate of “industrial education,” which included agriculture, engineering, and liberal arts instruction. This study of the early years of engineering education at Midwestern land-grant colleges also provides important insights into the nature of Midwestern culture and the changing nature of professionalism for middle-class Americans in frontier states.¹

During the second half of the nineteenth century, leaders across the nation established, organized, and extensively modified their institutions. Before examining the individual state schools, chapter two provides an analysis of eastern scientific and technical schools, as well as the philosophy and career of Robert Thurston. Thurston and fellow engineering professors also organized, promoted, and led numerous national engineering societies, such as the American Society of Mechanical Engineers, the American Society of Civil Engineers, and the Society for Promoting Engineering Education. By the 1890s, engineering professors and professionals helped inject a new emphasis on standardizing and professionalizing the engineer’s education, practical training, and work experience.

¹ Recent scholarship that focuses primarily on engineering education or scientific and engineering schools includes *Engineering in a Land-Grant Context: The Past, Present, and Future of an Idea* edited by Alan I. Marcus (West Lafayette: Purdue University Press, 2005); Julius Stratton and Loretta Mannix, *Mind and Hand, The Birth of MIT* (Cambridge: The MIT Press, 2005); *The Engineer in America, A Historical Anthology from Technology and Culture* edited by Terry S. Reynolds (Chicago: The University of Chicago Press, 1991); Robert McMath Jr. et. al., *Engineering the New South, Georgia Tech, 1885-1985* (Athens: The University of Georgia Press, 1985); and Edwin T. Layton, Jr., *The Revolt of the Engineers, Social Responsibility and the American Engineering Profession* (Baltimore: The Johns Hopkins University Press, 1986). A few of the older scholarly works on engineering and professionalism are Daniel Calhoun, *The American Civil Engineer, Origins and Conflict* (Cambridge: Harvard University Press, 1960); Monte A. Calvert, *The Mechanical Engineer in America 1830-1910* (Baltimore: The Johns Hopkins Press, 1967); and Burton J. Bledstein, *The Culture of Professionalism, The Middle Class and the Development of Higher Education in America* (New York: W.W. Norton & Company, Inc., 1976). One example of a local and specialized manufacturing endeavor is John K. Brown, *The Baldwin Locomotive Works 1831-1915* (Baltimore: The Johns Hopkins University Press, 1995).

Thurston's career as a college professor and engineering society leader served as both a model and foil for administrators and professors at other institutions. Many Midwestern school administrators toured the eastern schools as a part of their building and curricula planning, which they then incorporated into their own plans for agricultural and applied science, along with other industrial arts as mandated by the language of the 1862 Morrill Act.

Midwestern administrators also took into consideration the needs and opportunities of their specific states. While Michigan, Wisconsin, Iowa, and Nebraska had numerous differences in population, industry, and institutional focus, they also had many similarities. Each school faced the challenge of balancing the agricultural and mechanic arts mandates of the 1862 Morrill Land-Grant bill with local economic concerns. Professors and students also had to weather periods of trial and error, equipment and funding shortages, and changes in educational philosophies and emphases as presidents and professors came and went. *A Culture of Technical Knowledge* examines the emerging nature of engineering education in these Midwestern schools in conjunction with the political and economic changes that also took place at the state, regional, and national levels during the late-nineteenth century.

A Culture of Technical Knowledge concludes with an analysis of the subsequent restructuring of engineering programs at land-grant colleges in Michigan, Wisconsin, Iowa, and Nebraska. By the turn of the century, administrators and professors had begun implementing curricular changes, created specialized departments for the various engineering disciplines, and found new sources of funding to enhance their laboratory and training programs. The work of engineering professors and administrators, through

teaching, providing engineering expertise for their state, and promoting national society meetings and publications, provided a more standardized engineering curriculum and professional opportunities for lower and middle-class Americans.

In the late-nineteenth century, educators encountered rapidly changing public expectations, regional needs, and employment requirements. College administrators and professors recognized a dire need for technically skilled individuals who could quickly adapt to changes in equipment and processes, and implement advances in scientific knowledge in American homes, fields, and factories. These skilled workers also needed to attain respectable status as professionals in order to claim the prerogative to mold and guide America's industrial economy. Leaders of land-grant institutions, funded by the 1862 Morrill Act and given the mandate to "teach such branches of learning as are related to agriculture and mechanic arts" took it upon themselves to implement a new education based on scientific principles and practices that would empower the industrial classes and promote a culture of technical knowledge in America.²

The research for the following work draws out the central role played by agriculture and engineering at land-grant colleges in this process, citing how institutional leaders promoted the benefits of science and technology through their individual efforts and how land-grant institutions contributed to the further industrialization of an already technical society. *A Culture of Technical Knowledge* argues that Midwestern land-grant colleges, as newly established institutions with some innovative teachers and open-minded students, provided the vanguard for the professionalization of engineering in the

² *The Land-Grant Tradition* (Washington D.C.: The National Association of State Universities and Land-Grant Colleges, 1995), 12. This publication reprints the entire 1862 Morrill Land-Grant Act, along with its subsequent amendments.

United States. Land-grant administrators and professors argued that technical knowledge – encompassing science and mathematical theory, mechanical applications, critical thinking skills and methods, and engineering innovations – had to become an educational priority and a focus of an industrial society and culture. *A Culture of Technical Knowledge* addresses these transformations by examining the culture of nineteenth-century mid-western land-grant institutions – the refinement and system of ideologies, curricula, and training methods – during their formative years. This work also touches on the local debates between governments and institutions regarding service to constituencies, which resulted in a new balance between institutional and professional control of engineering and technical training. By examining the ideologies and practices of early land-grant college professors and students, this research connects the intellectual approaches to science and engineering education with the changing cultural expectations of an industrial society in the late nineteenth-century.³

During most of the nineteenth century, farmers, scientists, and mechanics acquired technical competence through hands-on training or apprenticeships. Between 1820 and 1850, however, the demand for formally trained scientists and engineers outpaced the ability of the few existing technical schools, such as the Military Academy at West Point and Rensselaer Polytechnic Institute, to produce them in adequate numbers. In 1918, Charles Mann, a physicist at the University of Chicago, discussed this imbalance

³ On the history of the Morrill Land-Grant Act see Edward Eddy, *Colleges for our Land and Time: The Land-Grant Idea in American Education* (New York: Harper & Brothers Publishers, 1957); Earle D. Ross, *Democracy's College, The Land-Grant Movement in the Formative State* (New York: Arno Press & The New York Times, 1969); Roger L. Williams, *The Origins of Federal Support for Higher Education: George W. Atherton and the Land-Grant College Movement* (University Park: Pennsylvania University Press, 1991); and Coy F. Cross II, *Justin Smith Morrill: Father of the Land-Grant Colleges* (East Lansing: Michigan State University Press, 1999), 77-94.

as a part of his report on the state of engineering education and the growth of American industry, firmly establishing the historical problem of producing qualified and professional engineers in America.⁴

By the 1850s, established humanities colleges, such as Harvard and Yale, had added scientific schools while state governments, like Michigan and Massachusetts, began to support agricultural and engineering training by funding independent agricultural and technical colleges. Even so, these early schools promoted technical improvements at a primarily local or limited regional level, while technical coursework remained largely secondary to classical studies in the humanities at eastern colleges and most state universities.⁵

In 1862, Congress passed Justin Morrill's bill to support agricultural and mechanic arts colleges in every state "in order to promote the liberal and practical education of the industrial classes." Though Morrill's phrasing left the method of education open to individual interpretation, he hoped that a practical science curriculum "would do the greatest good for the greatest number." However, at many institutions, debates soon arose over how to best implement a scientific curriculum and technical training regimen that went beyond duplicating the experiences gained in the home, on the farm, or in the workshop to foster a technically competent and productive society.⁶

⁴ Charles Riborg Mann, *A Study of Engineering Education, Prepared for the Joint Committee on Engineering Education of the National Engineering Societies*, Bulletin 11 (New York: Carnegie Foundation for the Advancement of Teaching, 1918).

⁵ On non-academic technical training in America during the nineteenth century see Bruce Laurie, *Artisans into Workers: Labor in Nineteenth-Century America* (New York: Hill and Wang Press, 1989). On pre-Morrill Act technical agricultural colleges see Charles R. Mann, *A Study of Engineering Education* (New York: Carnegie Foundation for the Advancement of Teaching, Bulletin 11, 1918).

⁶ On Justin Morrill's educational ideology and intentions for federal funding see Coy F. Cross II, *Justin Smith Morrill: Father of the Land-Grant Colleges* (East Lansing: Michigan State University Press, 1999), 79. For the debate on how to implement a scientific curriculum in a rural setting see Earl D. Ross, *A*

The struggle over what to teach and how to teach it illuminates the larger struggle of how to define technical education and technical knowledge as well as the means through which and setting in which individuals could best acquire it. Scholars Hamilton Cravens and Alan Marcus wrote that technical knowledge is the public discourse of specialized professionals that run society, the economy, politics, and culture. Certainly, the technical knowledge surrounding engineering in the late-nineteenth century became an integral part of what students learned and how they learned it, in essence the culture of education for engineering students.⁷

However, the historians George Brown Tindall and David Shi noted that the word “culture” was transformed by anthropologists around the turn of the century. Prior to 1900, people defined “culture” as the refinement of processes, thought, and action. After 1900, society began using “culture” to refer to an entire system of ideas, folkways, and institutions within which any group lived. The groups investigated for this work, particularly in the Midwest, followed this trend. Prior to 1890, administrators and professors before 1890 worked to refine their educational activities and fine tune their teaching methods, if not implement whole-sale changes. Beginning in the early 1890s, and continuing into the 1900s, professors increasingly looked at the entire system in which they worked, not just institutionally or regionally, but nationally as well. Engineering, and the technical education and knowledge they employed and developed,

History of Iowa State College of Agricultural and Mechanic Arts (Ames: Iowa State College Press, 1942), 59. See also Joseph Bailey, *Seaman A. Knapp: School Master of American Agriculture* (New York: Columbia University Press, 1945), 80-81.

⁷ Hamilton Cravens, Alan I Marcus, and David M. Katzman, *Technical Knowledge in American Culture: Science Technology, and Medicine Since the Early 1800s* (Tuscaloosa: The University of Alabama, 1996), 1-18.

grew from a refinement of practical knowledge and applicable skill to a system of knowledge and expertise accepted by the entire engineering community.⁸

Ostensibly, state and institutional leaders established and organized land-grant colleges funded by the 1862 Morrill Act to provide a “liberal and practical education” for America’s farmers, mechanics, and laborers. Yet, different constituencies and factions within the colleges vied for control of the curriculum, seizing on its centrality in the perception of both school and state in an emerging technical society. Their battles underscore the fact that these institutions understood their potential role in improving the status of farmers, mechanics, and laborers as well as their mandate to shape the future productivity of society itself.

Though not discussed specifically in connection with this work on engineering education, the story of administrators’ and professors’ ideas and actions at Midwestern land-grant institutions parallels the changing nature of political economy in nineteenth-century America. Statesmen, politicians, and public figures approached the idea of political economy as those things which benefited or worked in favor of the public interests. But the public’s interests changed, or were perceived as changing over the course of the nineteenth-century. Prior to the Civil War, American political economy dealt with expanding, developing, and building the necessary infrastructure and

⁸ George Brown Tindall with David E. Shi, *America, A Narrative History*, 3rd edition (New York: W.W. Norton & Company, 1992), 1046-1047. Tindall and Shi reference several works that they based their theoretical ideas on for “modernism.” See Daniel J. Singal, *The War Within: From Victorian to Modernist Thought in the South, 1919-1945* (Chapel Hill: University of North Carolina Press, 1982); Morton G. White, *Social Thought in America: the Revolt Against Formalism* (New York: Viking Press, 1952); Morton G. White, *A Philosophy of Culture: the scope of holistic pragmatism* (Princeton: Princeton University Press, 2002); Ruth Benedict, *Patterns of Culture* (Boston: Houghton Mifflin, 1959); Stanley Coben, *Rebellion against Victorianism: the impetus for cultural change in the 1920s America* (New York: Oxford University Press, 1991); and Stanley Coben and Lorman Ratner, *The Development of an American Culture* (Englewood Cliffs, NJ: Prentice-Hall, 1970).

institutions of the United States. After the Civil War, Americans' began to view political economy as the process of managing growth, maintaining institutional balance, and promoting innovation and entrepreneurship. Educators placed themselves firmly within these definitions of political economy as they worked to organize, expand, and promote their colleges and universities.⁹

Politicians also wrote charters and ordinances promoting the broad scale of learning available at the new land-grant colleges, while college administrators and professors attempted to institute educational practices based on personal ideology and perceived public demand. Broad-based as well as narrowly focused proponents of education both pressed their demands, highlighting the contentious nature of technical education in the late-nineteenth century. Supporters of a broad-based liberal education believed that Midwest land-grant schools should provide a wide range of studies,

⁹ A number of older and newer works on American political economy address the topic in various ways. For the Jacksonian and antebellum period see Francis Bowen, *The Principles of Political Economy applied to The Condition, the Resources, and the Institutions of the American People*, 2nd edition (Boston: Little, Brown, and Company, 1859); Douglass C. North, *The Economic Growth of the United States, 1790-1860* (Englewood Cliffs, NJ: Prentice-Hall, Inc, 1961); Harry L. Watson, *Liberty and Power: The Politics of Jacksonian America* (New York: Hill and Wang, 1990); Edward Pessen, *Jacksonian America: Society, Personality, and Politics* (Homewood, IL: The Dorsey Press, 1969); *The many-faceted Jacksonian era: New Interpretations*, edited by Edward Pessen (Westport, CT: Greenwood Press, 1977); and Charles Sellers, *The Market Revolution: Jacksonian America 1815-1846* (New York: Oxford University Press, 1991). The short period between 1850 and 1865 has received limited attention with regards to political economy. Three works that do provide some historical analysis are Eric Foner, *Free Soil, Free Labor, Free Men: The Ideology of the Republican Party Before the Civil War* (New York: Oxford University Press, 1995); Heather Cox Richardson, *The Greatest nation of the Earth: Republican Economic Policies During the Civil War* (Cambridge: Harvard University Press, 1997); and Richard Franklin Bense, *Yankee Leviathan: The Origins of Central State Authority in America, 1859-1877* (New York: Cambridge University Press, 1990). For analysis and discussion of American political economy in the post-Civil War era through the end of the nineteenth-century and into the early twentieth century see Francis Bowen, *American Political Economy: Including strictures on the management of the currency and the finances since 1861* (New York: Scribner, Armstrong, and Co., 1874); J. Elliot Cairnes, *Essays in Political Economy, Theoretical and Applied* (London: MacMillan and Co., 1873); Terry L. Anderson and Peter J. Hill, *The Political Economy of the American West* (Lanham, MD: Rowman & Littlefield Publishers, 1994); Elizabeth Sanders, *Roots of Reform: Farmers, Workers, and the American State, 1877-1917* (Chicago: The University of Chicago Press, 1999); Richard F. Bense, *The Political Economy of American Industrialization, 1877-1900* (New York: Cambridge University Press, 2000); and Marshall E. Dimock, *The New American Political Economy, A Synthesis of Politics and Economics* (New York: Harper and Brothers Publishers, 1962).

including theoretical sciences, business courses, and modern languages, as well as rhetoric, Latin, and philosophy. Their pedagogical ideals also included some practical skill training in the laboratory and shop so that students could apply the principles learned in the classroom to the real world or at least understand how to apply technical principles. By contrast, those who embraced a more narrow focus desired an intensive practical and applied course of agricultural and mechanical arts instruction, with less classroom study and more time spent in the shop and field acquiring skills necessary for farming and industrial work.¹⁰

These debates over both the means and the methods for designing a quality technical education are at the heart of *A Culture of Technical Knowledge*, in order to demonstrate the overarching importance of land-grant institutions in contributing to American technical knowledge and its evolution from a self-trained craft status to a professional endeavor. In the 1860s and 1870s, land-grant colleges utilized manual labor training to placate public demands for skilled graduates who would return to the local farms and businesses, while building infrastructure and accumulating capital. Students worked in the schools' kitchens, laundries, fields, and shops so they could implement and practice new concepts and skills. However, many professors, along with the general public, saw too many similarities between such manual labor training and the skills naturally acquired on farms and in factories. In the late 1870s, as part of their effort to distinguish their pedagogy, professors at key Midwest schools began implementing various combinations of shop practice based on the Russian and Worcester Polytechnic Institute methods. Still, they downplayed the role of classroom theory in the

¹⁰ Earl D. Ross, *Democracy's College: The Land-Grant Movement in the Formative State* (Ames: Iowa State College Press, 1942), 87-89.

development of technical knowledge and placed more emphasis on practical, established skills which would benefit the graduates in their future work. Instructors soon realized that the lack of theoretical knowledge placed limits on the usefulness of the worker and diminished the role and advancement of technical knowledge in the larger scope of society. By the latter 1880s and in the 1890s, laboratory practice coupled with classroom learning became more widely accepted. *A Culture of Technical Knowledge* shows that professors, utilizing better equipped laboratories and research methods, more readily demonstrated to students how theory and practice intermingled and advanced technical knowledge. Moreover, they did so in response to the fact that businesses and society now placed a higher premium on scientifically trained and technically competent graduates and their professions.¹¹

The ascendancy of scientists and engineers to higher levels of professional status required both the popular acknowledgement of their special skills and training and the advancement of organizations which promoted them as true professionals. Professional groups like the American Society of Civil Engineers and the American Institute of Mining Engineers had existed since the 1850s and 1860s. However, engineering instructors felt academically and financially slighted by the American Association of Agricultural Colleges and Experiment Stations, begun in 1879, because of its exclusive focus on agricultural research and education. Led by Robert Thurston, engineers and professors created the Society for Promoting Engineering Education in 1893 to promote

¹¹ See Monte Calvert, *The Mechanical Engineer in America, 1830-1910* (Baltimore: The Johns Hopkins Press, 1967), 1-87, and Richard Overfield, *Science with Practice: Charles E. Bessey and the Maturing of American Botany* (Ames: Iowa State University Press, 1993), 1-46. The importance of college training in science and technical expertise to business, industry, and society is briefly discussed in David F. Noble, *America By Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Oxford University Press, 1977), 39-49.

engineering educational goals, increase standardized curriculums among American engineering colleges, and provide a lobbying group for federal aid to land-grant colleges.¹²

Thurston represents the archetypal East coast example of the professional educator. As an engineering instructor with lengthy tenures at the U.S. Naval Academy, Stevens Institute of Technology, and the Sibley College of Mechanical Engineering at Cornell University, Thurston extolled the educational virtues of original research, extensive publication, and collaborative efforts between businesses and schools. To demonstrate his pivotal role in defining a fundamental connection between professionalization and its relationship to the importance of technical knowledge in America, this work posits that his 1892 article “Technical Education” supplied the necessary impetus to organize technical education on a national scale, to coordinate instruction with professional objectives, and to promote the virtues of technical knowledge in a modern, industrial society. Drawing directly from over four decades of classroom teaching and laboratory research, Thurston outlined what he believed to be the most modern and advanced coursework in the world along with the underlying principles of technical education which focused on rigorous classroom study and laboratory practice. As he noted, “the dominant characteristic of the [nineteenth] century has been

¹² For a detailed study of the origins of engineering societies, see Edwin Layton, *The Revolt of the Engineers* (Cleveland: The Press of Case Western Reserve University, 1971). While a few articles on the history of SPEE exist, no book length study of the professional society has been conducted at this time. See Terry Reynolds and Bruce Seely, “Striving for Balance: A Hundred Years of the American Society for Engineering Education.” *Journal of Engineering Education*, Vol. 82, No. 3 (July 1993): 136-151

the introduction of technical education: the instruction of youth...needed to make the pupil capable of doing a man's or woman's work in the world.”¹³

Scholarship on the role of American technical education, professionalization, and cultural trends in the late nineteenth-century remains limited, though historians have recently begun exploring these issues. This particular work addresses the need to better understand the educational changes of this era, as well as their impact into the twentieth century, by proving that a vital piece of our modern culture of technical knowledge originated at mid-western land-grant colleges with the implementation of new educational practices which relied on scientific and practical curricula. Within this framework, students encountered shifting attitudes and conceptions regarding instruction and the application of technical knowledge as it related to American society. However, *A Culture of Technical Knowledge* suggests the professionalization of engineering education improved the status and recognition of all land-grant college graduates. Taking a wider view of technical education and professionalization in the United States, this work also investigates how national education views intermingled by the turn of the century. Robert Thurston's published research and intellectual statements provide a compelling portrait of the connection between the philosophies of land-grant education, the professionalization of science and engineering, and the importance of technical knowledge to American culture in the 1890s.¹⁴

¹³ Robert Thurston, “Technical Education in the United States: It's Social, Industrial, and Economic Relations to Our Progress,” *Transactions of the American Society of Mechanical Engineers*, Vol. 14 (1893): 866-867.

¹⁴ For recent work on land-grant colleges and their role in shaping late-nineteenth century America see, Alan Marcus, “If All the World Were Mechanics and Farmers: Democracy and the Formative Years of Land-Grant Colleges in America,” *Ohio Valley History*, Vol.5, No. 1 (Spring 2005): 23-36; and David Harmon, “Collegiate Conflict: Internal Dissension at Land-Grant Colleges and the Failure to Establish

In order to understand the importance of technical education in late-nineteenth century American society, we must gain a better understanding of the goals and practices of land-grant schools which emphasized the value inherent in creating a culture of technical knowledge. Mapping the various forms and methods of technical education throughout the nineteenth-century, this work relies on technical journals, national and local newspapers, state and college documents regarding the organization and establishment of institutions, state educational reports, and college student documents. In institutional journals and society proceedings, educators and professionals recorded their ideologies, educational principles, and laboratory research. They defined what constituted professional status and behavior while also expanding the very nature of technical knowledge and its applications. Today's educators, striving to redefine science and technical skills in a rapidly changing environment, can learn a great deal from early land-grant educators who formulated new approaches to the concept of technical knowledge and its place in American society.

CHAPTER 2.

EDUCATION AND ENGINEERING IN THE AMERICAN EAST

Advocates of scientific and technical education in America during the second half of the nineteenth century dealt with rapidly changing public expectations, regional needs, and employment requirements. At the same time, engineering instructors and professionals struggled to create a strong and lasting educational basis for themselves in a rapidly industrializing society. As engineers increasingly focused on specialization and professionalization, college faculty, particularly at fledgling mid-western land-grant institutions, developed and applied varying combinations of practical shop work and classroom instruction to address public desires and engineers' concerns.

College educators, including Harvard's Charles Eliot, Yale's Daniel Coit Gilman, and Cornell's Robert Thurston, formulated and promoted new systems of scientific education and training. Eliot, Gilman, and especially Thurston combined traditional approaches with nineteenth century science and technology developments. Proponents of this "new education" emphasized its value and central nature at the newly established land-grant colleges. Robert Thurston provided one of the more detailed examinations of scientific education's development through his own work in the field.¹ Land-grant college administrators and professors offered an ideal testing ground for state-supported, practical science and engineering education. However, instructors wrestled with local educational needs, unstable admissions and funding, and ever-changing course materials.

¹ Robert Thurston worked at the Stevens Institute of Technology from 1871 to 1885 as the chair of the engineering. He spent the rest of his career, from 1885 to 1903, as the director of Cornell's Sibley College and professor of mechanical engineering. See William F. Durand, *Robert Henry Thurston, a Biography*. (New York: The American Society of Mechanical Engineers, 1929).

The Rise of Eastern Technical Schools

Despite the emergence of large-scale industry and building projects, most Americans in the mid-1800s still relied on small, widely dispersed manufacturing establishments. Mechanics maintained and repaired the implements of the farm, the tools of the shop, and the machinery of the factory. Engineers designed new tools and machines, and planned new bridges and roads. Owners of technically oriented businesses in the second quarter of the nineteenth century typically maintained a limited staff of no more than 10 men, usually trained in-house as apprentices. However, by the 1850s and 1860s, businesses and schools struggled to meet the growing demand for skilled mechanics and engineers as industry grew and the nation expanded westward.²

While hands-on training and apprenticeships dominated the American landscape, entrepreneurs and philanthropists offered several other types of technical training prior to the Civil War. Besides establishing scientific schools in the Northeast, they opened mechanics and workingmen's "institutes", operated community lyceums, published newspapers, journals, and magazines, ran libraries and book loan programs, and opened museums. Promoters and educators encountered steady success for their institutes, lectures, and publications through the 1840s. However, beginning in the mid-1850s they started directing most of their efforts towards informing the individual about the "latest-and-greatest" inventions and concepts of industry and business, rather than furthering scientific inquiry or engineering innovation.³

² See Eric Foner, *Free Soil, Free Labor, Free Men: The Ideology of the Republican Party Before the Civil War* (New York: Oxford University Press, 1995); Monte Calvert, *The Mechanical Engineer in America: Professional Cultures in Conflict, 1830-1910* (Baltimore: The Johns Hopkins Press, 1967); and Daniel H. Calhoun, *The American Civil Engineer: Origins and Conflicts* (Cambridge: Harvard University Press, 1960).

³ See Russel B. Nye, *Society and Culture in America* (New York: Harper and Row Publishers, 1974), 359-372. The character of agricultural and mechanic arts instruction, along with the definition of a mechanic,

Future engineers did have a limited number of options for more advanced and rigorous education in the first half of the nineteenth century. However, unless they were willing to travel to Europe, they had only a handful of East Coast schools to choose from. In 1802, the federal government established the first American technical school as part of the Military Academy at West Point, New York. However, professors did not conduct full-time classes in science and engineering until 1817. Though West Point primarily focused on military training, students also gained a reputable education in engineering and the institution provided the majority of civil engineers formally trained in the United States prior to 1890.⁴ In 1824, Stephen van Rensselaer established the Rensselaer Polytechnic Institute in Troy, New York. Through the 1830s, these two institutions shared the responsibility for supplying America with trained engineers, while also encountering the persistent demand for new scientific information and technical knowledge to increase production in American fields and factories.⁵

Through the 1850s and into the 1860s, state and business leaders continued confronting a pressing need for professionally trained scientists and engineers. Their main difficulties lay in finding adequate funding, hiring competent instructors, and adapting a useful curriculum. Many of the first scientific schools began as technical departments for already established institutions. Lawrence Abbot provided a gift of \$100,000 to found the Lawrence Scientific School at Harvard in 1847. The University of

underwent enormous changes between the 1830s and 1860s. However, observers noted little consensus on how farmers and mechanics should be instructed. For more on the intellectual and social character of agricultural and industrial instruction prior to the passage of the 1862 Morrill Land-Grant Act see Alan I Marcus, "If All the World Were Mechanics and Farmers: Democracy and the Formative Years of Land-Grant Colleges in America," *Ohio Valley History*, Vol. 5 (Spring 2005): 23-36.

⁴ Robert Thurston, "Technical Education in the United States: Its Social, Industrial, and Economic Relations to Our Progress," *Transactions of the American Society of Mechanical Engineers*, Vol. 14 (1893): 921-922.

⁵ Charles Mann, *A Study of Engineering Education* (New York: Carnegie Foundation for the Advancement of Teaching, Bulletin 11, 1918), 4-5.

Michigan, organized in 1817, fully established its engineering school in 1852. Yale College organized a scientific school in 1847, renaming it the Sheffield Scientific School in 1860 when Joseph E. Sheffield provided a \$100,000 endowment. In 1861, the state of Massachusetts founded an Institute of Technology to instruct “the masses of the people engaged in industrial occupation” so they could effectively “avail themselves of the advantages to be derived from the labors of those who are wholly devoted to purely scientific research.”⁶

Even with these substantial gifts, college leaders and instructors struggled to find satisfactory methods of training engineers and scientists at these new technical schools. Most early administrators worried about the cost of adding new courses to already established curricula, resulting in two common strategies. The first, tried at the Rensselaer Polytechnic Institute in the 1830s, treated engineering as a graduate program by adding a year of specialized study after completion of the liberal arts degree. Other colleges experimented with a second option, placing science and engineering courses outside the regular curriculum as non-degree courses, or else offering engineering classes within general Bachelor of Arts or Science curricula.⁷

Due to these ad-hoc methods of instruction, continual debates ensued between administrators and faculty about what kinds of technical instruction students needed to receive, educators agreed that the old-line colleges, Harvard, Yale, and other colleges

⁶ Robert Thurston, “Technical Education in the United States: Its Social, Industrial, and Economic Relations to our Progress,” *Transactions of the American Society of Mechanical Engineers*, Vol. 14 (1893): 921-922. Thurston briefly discussed the origins, organization, and focus of many of the first American scientific and engineering schools. He also included the State Normal Art School at Boston, the Technical Departments of Dartmouth College, the Worcester Polytechnic Institute, Columbia College School of Mines, the Cooper Institute of New York City, the Stevens Institute of Technology, the Technical Schools of Cornell University, and several smaller private endowments.

⁷ Terry S. Reynolds, “The Education of Engineers in America before the Morrill Act of 1862,” *History of Education Quarterly*, (Spring 1993): 45-50.

with classically oriented curricula, did not offer appropriate technical instruction. Reporting to the Brown Corporation, the governing board of Brown University, in 1850, Francis Wayland, the University president, summarized the plight of the traditional American college: “Our colleges are not filled, because we do not furnish the education desired by the people. We have produced an article for which the demand is diminishing. We sell it at less than cost, and the deficiency is made up by charity. We give it away; and still the demand diminishes.”⁸

Regardless of political and public outcries for more technical experts and many educators’ attempts at creating partial forms of specialized technical education in the 1840s and 1850s, science and engineering remained minor concerns for the instructors and students who remained steadfastly supportive of the more classical studies in the humanities. Administrators and faculty at the established east coast colleges, Harvard, Yale, Brown, and the like, firmly believed that the only profitable education remained firmly based in classical instruction. The working class, they maintained, could only learn their craft by apprenticing in the workshops and manufacturing centers. Technical knowledge to them meant practical skill, not scientific theory applied to research or industrial innovation.⁹

Instructors who wished to conduct more research, or at least work in a setting more tightly focused on science and engineering, had to take on contract work from businessmen or compete for the few positions available at dedicated scientific schools on the East coast, such as the Lawrence Scientific School at Harvard, Sibley College at

⁸ Quoted and analyzed in Francis. A. Walker, *Discussions in Education*, ed. by James Phinney Munroe. (New York: A. Holt Publishing, 1899), 82.

⁹ Classical studies focused on Greek, Latin, Rhetoric, and Philosophy with basic mathematics and possibly some rudimentary science added in the junior or senior year. See Earl D. Ross, *Democracy’s College* (Ames: The Iowa State College Press, 1942), 8-13, 86-90.

Cornell, or Sheffield Scientific School at Yale. Students who pursued scientific or engineering careers had to cope with constant changes in professors, instructional methods, and professional expectations. Even into the 1880s, industrialists held that students should learn general mathematics and science skills in school and then gain specific engineering knowledge on the job.¹⁰

However, as scientific knowledge expanded and machinery became more complex, engineers encountered a critical need for more intensive and specialized training. Industrialists, scientists, and engineers pleaded their cases through local pamphlets and petitions, and reports to legislative bodies in eastern states between 1820 and 1860. Even educators at the most prestigious American colleges appealed for changes. In his 1869 inaugural address at Harvard, Charles Eliot acknowledged that “prevailing methods of teaching science, the world over, are, on the whole, less intelligent than the methods of teaching language.”¹¹

American opinions were bolstered by European visitors as well. As early as 1831, Alexis De Tocqueville recognized a “natural interest and unusual opportunity in the new republic in the practical utilization of science.” He concluded his observations by stating, “It is evident, that, in democratic communities the interest of individuals, as well as the security of the commonwealth, demands that the education of the greater

¹⁰ For a detailed description of what engineering professors dealt with in their careers see William F. Durand, *Robert Henry Thurston: A Biography* (New York: The American Society of Mechanical Engineers, 1929). On student expectations and their business training see Monte Calvert, *The Mechanical Engineer in America: Professional Cultures in Conflict, 1830-1910* (Baltimore: The Johns Hopkins Press, 1967); and Daniel H. Calhoun, *The American Civil Engineer: Origins and Conflicts* (Cambridge: Harvard University Press, 1960).

¹¹ Charles Eliot, *Educational Reform, Essays and Addresses* (New York: The Century Co., 1909), 6. For further comments on science teaching before 1860, see Edward Orton, “The Contribution of Mechanic Arts to Educational Progress,” *Rutgers College: The Celebration of the One Hundred and Fiftieth Anniversary of its Founding as Queen’s College, 1766-1916* (New Brunswick: Rutgers College, 1917), 273-275. Public opinions on industrial education found their way into publications such as *Scientific American*, *The Cincinnati Enquirer*, *De Bow’s Review*, and *The New York Tribune*.

number should be scientific, commercial, and industrial, rather than literary.”¹² The majority of Americans worked in fields or shops, so for a democratic education to truly address the needs of the people, it had to address the needs of agriculture and industry.

Philosophies of Education

Through the 1850s, political and public support for a “people’s college”, which might address the agricultural and industrial needs of the country, grew stronger. Finally, in 1862, Congress passed the Morrill Land- Grant Act, which provided public lands to support and maintain at least one college in each state where “the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislature of the state may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in their several pursuits and professions in life.” This loose wording provided an outline for state legislators and educators to follow. Clearly, science and engineering were to be the cornerstones of the new colleges. Though the operational language of the 1862 act provided a framework, the bulk of the legislation dealt with land and funding allocation, rather than specific orders for organizing the curriculum. So how would educators actually construct the requisite curriculum?¹³

Since political leaders left considerable ambiguity in the 1862 Morrill Act’s phrasing and terminology, educational leaders and faculty found that they suddenly

¹² Alexis de Tocqueville, *Democracy in America* (New York: The Century Co., 1898), 47-52, 75-76.

¹³ *The Land-Grant Tradition* (Washington D.C.: The National Association of State Universities and Land-Grant Colleges, 1995), 12. For the history of the 1862 Morrill Act see Ross, *Democracy’s College*, 46-68, and Williams, *The Origins of Federal Support for Higher Education*, 1-54; for details on Justin Smith Morrill see Coy F. Cross, *Justin Smith Morrill: Father of the Land-Grant Colleges* (East Lansing: Michigan State University Press, 1999).

gained freedom to adapt their courses and programs to meet the apparent needs of a rapidly changing society. Morrill and his supporters intentionally structured the legislation so as to fund schools for agriculture and mechanic arts without excluding humanities and other sciences. This flexibility enticed professionals who saw a need for better education for larger parts of society and social reformers who wanted more practical education for working class citizens.¹⁴

Educational leaders and college administrators immediately attempted to incorporate scientific instructional methods of the 1870s and 1880s into their curricula. Many faculty incorporated lecture demonstrations, field work and observation, and simple experiments which the students could do with readily available items. They developed methods of professionalization for academic studies such as engineering, horticulture, livestock breeding, and surveying, with the help of leaders in businesses and professional societies. They also debated between traditional methods of education and attempts to modernize the classroom, teaching techniques, and laboratory practices. Educators saw a chance to use science as the primary vehicle for the transmission of knowledge and the development of reasoning skills, while promoting the college as a unique institution which met the demands of the public. Administrators also began to promote the idea of creating a better society with the technical expertise and professionalization of its graduates.¹⁵

The 1862 Morrill Land-Grant Act provided the means for technical, scientific education. Under the system funded by this legislation, the “sons and daughters of

¹⁴ John Y. Simon, “The Politics of the Morrill Act.” *Agricultural History*, Vol. 37 (April 1963): 103, 109-111.

¹⁵ W. J. Kerr, *The Spirit of the Land-Grant Institutions* (Address delivered at the Forty-fifth Annual Convention of the Association of Land-Grant Colleges and Universities at Chicago, Ill, November 16-18, 1931), 8-12.

[America's] farmers and mechanics" could obtain a free education that focused especially on their chosen vocations. But it took of decades of educational debate, innovation, and healthy doses of foresight to provide the foundation for a "new education" which educators could apply and adapt to their institutional needs, and from which students could actually benefit. Daniel Coit Gilman and Charles W. Eliot provided this summation by addressing the unique character of schools of science and the need for a modern system of education. Gilman presented his ideas in "Our National Schools of Science", published in the *North American Review* in 1867, and Eliot published his ideas in a set of landmark essays entitled "The New Education" for the *Atlantic Monthly* in 1869.¹⁶

Daniel Coit Gilman brought a unique perspective to the formation of state colleges and educational systems. Gilman graduated from Yale College with a classical education in 1852, but he fostered a strong interest in scientific observation and study throughout his academic career. He spent the next several years touring colleges and universities in Europe as a kind of post-graduate tour and on the request of professors at the Sheffield Scientific School who wanted a detailed report on innovations that European schools were adopting. He spent much of his time in Germany, studying their scientific and technical schools. Here, he also witnessed the status and honor heaped upon men engaged in the search for new knowledge. His European experiences and insights became a cornerstone of the treatise on science and higher learning that he wrote

¹⁶ The quote "sons and daughters of farmers and mechanics" was a phrase popularized by Earle Ross. See Earle D. Ross, *Democracy's College: The Land-Grant Movement in the Formative Stage* (Ames: The Iowa State College Press, 1942), 12. This particular phrase arose from the 1824 mission statement of the Rensselaer Institute in Troy, New York. However, the phrase became widely copied and became the basis for the operational language of the 1862 Morrill Land-Grant Act.

for the Yale Scientific School in 1855 and his involvement in the discourse about the emerging shape of land-grant college educational systems.¹⁷

Gilman brought a special understanding to the implementation of the Morrill Land Grant Act. During his years as the head librarian for Yale, Gilman successfully urged the Connecticut legislature to accept the 1862 Morrill Act funding to expand the Sheffield Scientific School. While in Washington, D.C. negotiating the funding particulars, Gilman became personally acquainted with Senator Justin Morrill. In 1867, when Senator Morrill visited Yale, he stayed with Gilman and provided detailed information about his intentions for introducing the 1862 Morrill Land Grant Act and his thoughts on the legislation's future implications. With this first-hand knowledge, Gilman effectively countered individuals in later years who wished to make their own interpretations of the legislation.¹⁸

Following his 1867 talks with Justin Morrill, Gilman organized his sentiments regarding the character and importance of the Land Grant Act and how schools should proceed to benefit from it. Rather than limit the designation to agricultural or technical schools, Gilman referred to the institutions covered as "National Schools of Science." He emphasized the fact that the schools had received both their funding and educational mandate from the national government, and so the nation deserved to "reap the benefits which they are designed to render."¹⁹

¹⁷ Fabian Franklin, *The Life of Daniel Coit Gilman* (New York: Dodd, Mead & Company, 1910), 55-70. See also, Verne A. Stadtman, *The University of California, 1868-1968* (New York: McGraw-Hill Book Company, 1970), 61-62. Gilman presented some specific details regarding technical universities in Britain, France, and Germany in his 1867 article "Our National Schools of Science." *North American Review* (Oct 1867): 515-516.

¹⁸ Verne A. Stadtman, *The University of California, 1868-1968* (New York: McGraw-Hill Book Company, 1970), 62.

¹⁹ Daniel Coit Gilman, "Our National Schools of Science." *North American Review* (Oct 1867): 496-497.

Despite Gilman's focus on the "national" character of the schools, he recognized that each state also had to address its own educational needs. Educators never convened a general conference with regards to the educational necessities of the overall country. Instead, state legislators and college administrators had already started to hammer out their own solutions, subject to the needs and wants of their constituencies. Gilman applauded these state efforts to combine the intent of the legislation with the unique requirements of local citizens, but lamented that little discussion on the "principles of mental training" occurred between educators. In his 1867 *North American Review* article, Gilman called for a public discourse between scholars to define the scope of these emerging institutions with respect to national needs while also incorporating a broader experience of educational philosophies and systems. Gilman also expressed frustration that even in the nation's prominent periodicals, there had been no thorough discussion of a national education system which relied on "science and letters as a means of discipline." Gilman saw significant benefits to instruction in modern science, language, and economic instruction as a way to train students from the middle class who populated and controlled the growing manufacturing and industrial centers of the United States. But these middle and working class students needed a curriculum that met the needs of a modern industrialized society, not a set of antiquated lessons based on dead languages and arcane rhetorical skills.²⁰

Gilman applied his definition of "scientific schools" in a very broad sense. He included the scientific schools of Harvard, Yale, Dartmouth, Union College, and Columbia as well as Rensselaer Polytechnic which provided scientific coursework "parallel but certainly not equal" in quality or status to the classical studies students

²⁰ Daniel Coit Gilman, "Our National Schools of Science." *North American Review* (Oct 1867): 498-499.

focused on. He praised the agricultural schools of New York, Pennsylvania, Michigan, and Illinois, which specifically addressed the practical needs of farmers. And he suggested that the “Institute of Technology” being organized in Boston might take a lead in training mechanical engineers and other manufacturing professionals. But while all these schools offered various forms of scientific and technical instruction, what Gilman reluctantly termed practical education, he worried that they had insufficient funding and no proper overall organization.²¹

Gilman grouped all the various kinds of scientific, agricultural, and technological schools together, but he took issue with the popular interpretation that the bill only applied to “Agricultural Schools.” He insisted that if “National Schools of Science,” his preferred term, did meet with public acceptance, then “Colleges of Agriculture and the Mechanic Arts,” “Industrial University” be used. At the very least, he insisted that “Scientific,” “Polytechnic,” or “Technological” School be used in order to alleviate the power of farmers and agricultural supporters to dominate the curriculum and educational system at the new institutions. He remained steadfastly loyal to the actual language of the Morrill Act, which included “agricultural and the mechanical arts” Gilman insisted that the “liberal education of the industrial classes was as much an object of the grant as their practical training.” Gilman envisioned using Morrill Act funds to create new and complete universities that addressed all the needs and desires of American society by applying specialized branches of learning and training, especially in science, agriculture, and engineering.²²

²¹ Daniel Coit Gilman, “Our National Schools of Science.” *North American Review* (Oct 1867): 500-501.

²² Daniel Coit Gilman, “Our National Schools of Science.” *North American Review* (Oct 1867): 506-607.

Gilman believed that the colleges funded by the Morrill Act needed to combine national and local necessities. Given the equal emphasis Gilman placed on local issues, he did not want one school to become the model copied all the rest. Residents of each state required specific kinds of instruction and while long-settled areas already possessed many institutions built around established systems and interests, the residents of newer states had the opportunity and the responsibility to address the particular characteristics of their state when organizing their new land-grant schools. He foresaw higher requirements and more difficult courses of instruction in the older states that had established colleges and universities. In the western farming states, Gilman projected, economic interests would force administrators to focus on agricultural studies. Gilman mentioned California, Nevada, and Pennsylvania as appropriate locations for future mining engineering studies. And he suggested that civil engineering, mechanics, chemistry, and business management should be left primarily to the eastern schools, since they were located near the nation's centers of industry and manufacturing. Gilman ignored the Midwest, viewing it as a largely unsettled and undeveloped region that possessed only the raw resources that Eastern industrialists could exploit to best advantage. He also implored the older institutions of the east to properly train men in scientific and technical studies so they could fill the professorial ranks at the new schools of science.²³

Gilman viewed higher education as a distinctly middle-class endeavor, and his vision for the schools of science did more to elevate the status of the industrial management classes than to improve the condition of working peoples. Gilman remarked that he did “not think it likely or desirable that young men go back and labor with the hoe

²³ Daniel Coit Gilman, “Our National Schools of Science.” *North American Review* (Oct 1867): 515-517.

or the anvil.” He wanted scientifically trained men to become the managers of mines, factories, and construction projects. Eventually, Gilman thought lower grade, local industrial schools would supply the need for laborers and skilled craftsmen, but only after educators at central state colleges had firmly established their reputations as the leaders in professional instruction. Gilman reserved the schools of science for highly specialized professions. He insisted that mechanics and farmers seek out useful scientific instruction at occasional lectures and in agricultural and trade journals, rather than fill up class space better left to those with greater management potential. In fact, Gilman recognized a widespread trend that sons of farmers already failed to return to the farm after three or four years at college. Though he advanced the idea that the future of the nation resided in schools of science, Gilman also clung to the idea that classical studies remained an important facet of liberal education for the upper classes. But he combined his enthusiasm for science and his respect for classics into a call for an improved system of higher education to benefit the entire nation.²⁴

Similarly to Gilman, Charles Eliot’s philosophies grew out of his personal educational experiences. Born into a Boston patrician family in 1834, he obtained his only experience as a public school student at the Boston Latin Grammar School. He often recalled that the traditional curriculum of Latin, Greek, and mathematics, with a little composition and history thrown in, was narrow and bleak compared to the “liberal and interesting curriculum” of scientific inquiry he later advocated. While he “endured” the traditional Latin school education, his parents provided Charles with other experiences. They provided lessons in carpentry and wood-turning, allowing him to pursue his interests in trade skills and organization, setting up a small shop in the back of

²⁴ Daniel Coit Gilman, “Our National Schools of Science.” *North American Review* (Oct 1867): 519-520.

their house. They also set up a hand press that Eliot and a fellow student used to print a weekly school paper, though Charles rarely wrote any articles.²⁵

In 1849, Eliot entered Harvard College at age fifteen, where he continued to experience the “limited” education experience of Latin, Greek, and philosophy, with only superficial instruction in the natural sciences. However, Eliot did teach himself some rudimentary chemistry from a textbook he acquired, immediately “exciting his curiosity.” Following these early investigations, Eliot sought out Josiah Cooke, Harvard’s professor of chemistry and began working in Cooke’s laboratory and traveling on the professors geological expeditions, continuing to accompany Cooke after he graduated.²⁶

Following his graduation in 1853, Eliot spent a year teaching science courses for high school age children at the Pitts Street School and the Boston Primary School. He then began nine years of service at Harvard College, teaching mathematics and chemistry. During this time, he maintained a strong interest in promoting and expanding scientific education through lectures, textbook writing, and experimentation. He attempted all of these activities at different points in his career, but was more successful at guiding others towards these practices in their own teaching careers. He also experienced the administrative side of education when he filled in as the dean of the Lawrence Scientific School in 1861.²⁷

Eliot spent two years of study in Germany and France, following his unsuccessful bid in 1863 for Harvard’s Rumford Professorship on the Application of Science to the Useful Arts. Colleagues criticized his lack of experience in chemical laboratory work, and the most prominent schools where Eliot could acquire expertise in such

²⁵ Henry James, *Charles W. Eliot*, Vol. 1 (Boston: Houghton Mifflin Company, 1930), 16-17, 18.

²⁶ Henry James, *Charles W. Eliot*, Vol. 1 (Boston: Houghton Mifflin Company, 1930), 44-49.

²⁷ Henry James, *Charles W. Eliot*, Vol. 1 (Boston: Houghton Mifflin Company, 1930), 61-75, 86-88

experimentation existed in Europe. However, while traveling, Eliot began devoting much of his time to the study of school systems and methods of instruction. He returned to America, accepting a faculty position in chemistry at Massachusetts Institute of Technology.²⁸

Eliot observed that students attempting to carry on scientific and classical studies simultaneously could never achieve their best, since they constantly split both class and study time between the two. However, Eliot did distinguish the efforts as “good temporary expedients during a transition period,” at universities like Brown and Michigan, or in “crude communities where hasty culture is as natural as fast eating. They do good service in lack of better things.” Certainly not a ringing endorsement, but Eliot conceded that some scientific and technical education was better than none.²⁹

During his final year at M.I.T., Eliot published the “New Education” articles that brought him to national attention as a proponent of modern, scientific education. In his “New Education” articles, Eliot scrutinized the achievements of three kinds of institutions which attempted to “organize a system of education based chiefly upon the pure and applied sciences, living European languages, and mathematics”; scientific “schools” connected to colleges, scientific “courses” within colleges, and the independent “schools” especially dedicated to non-classical education.³⁰ He concluded that scientific “schools” that had started out as professional schools where students gained additional instruction, similar to a law school, had proved completely unsuccessful. Colleges that utilized

²⁸ Henry James, *Charles W. Eliot*, Vol. 1 (Boston: Houghton Mifflin Company, 1930), 154-183. Eliot compiled ideas from numerous authors, most notably Herbert Spencer. For a brief description of Spencer’s ideas and their influence on Eliot see Lawrence A. Cremin, *The Transformation of the School: Progressivism in American Education 1876-1957* (New York: Vintage Books, 1961): 91-93. For a description of influential American educators before 1860 see Lawrence A. Cremin, *American Education: The National Experience 1783-1876* (New York: Harper & Row Publishers, 1980): 253-297.

²⁹ Charles W. Eliot, “The New Education.” *The Atlantic Monthly* (February 1869): 214-215.

³⁰ Charles W. Eliot, “The New Education.” *The Atlantic Monthly* (February 1869): 204.

scientific “courses” proved detrimental to both the student’s scientific coursework and classical studies. However, Eliot argued, the independent scientific schools had achieved success by organizing a curriculum which addressed scientific training and practical application in a concerted way.³¹

Supporters of the scientific schools, such as Yale’s Sheffield Scientific School and Harvard’s Lawrence Scientific School, established them specifically to avoid duplicating buildings, equipment, and faculty within their own institutions. However, each school did see significant duplication of facilities, apparatus, and professors, while only succeeding in sharing library collections. Eliot blasted the detractors of scientific education because they compared the new and untried methods with the deeply entrenched traditional methods. He also admonished the schools for poor recruitment of post-graduates and charged Yale with using its scientific school to raise the reputation of the entire institution while continuing with traditional methods.³²

Eliot’s true praise fell on independent schools, like the Massachusetts Institute of Technology and Rensselaer Polytechnic Institute. At these schools, students had four full years of scientific and applied coursework, along with modern languages like German and French which would allow them to read the latest scientific and technical information from Europe. Graduates of these institutions became fully recognized professionals after a period of rigorous training equal to that of classically trained individuals. However, Eliot felt that having obtained a truly scientific and practical education, students of

³¹ Charles W. Eliot, “The New Education.” *The Atlantic Monthly* (February 1869): 205, 214, and 217.

³² Charles W. Eliot, “The New Education.” *The Atlantic Monthly* (February 1869): 205-210. Many authors provided more favorable examinations of scientific “polytechnic schools” in their summaries of American schools, courses, and objectives. See S. Edward Warren, *Notes on Polytechnic Schools in the United States: Their Nature, Position, Aims and Wants* (New York: John Wiley and Son, 1866).

independent scientific schools would be immediately useful to the improvement of the nation's industries, infrastructure, and ultimately its very culture.³³

Though Eliot proposed his "new education" in a way that might appeal to a broad spectrum of social classes, he specifically tailored many of his arguments towards the established, independent scientific schools. He completely dismissed "institutions which exist only on paper, or which have been so lately organized," expressly mentioning the agricultural colleges and alluding to the larger state schools in the Midwest which had been in operation for less than a decade. However, Eliot misjudged the new land-grant colleges. With the promise of dedicated scientific and practical study, these newly formed colleges quickly attracted some of the most innovative American educators. Over upcoming years, these schools educated scientifically trained farmers, mechanics, and engineers who literally fed and built the burgeoning American heartland.³⁴

As the land-grant idea took hold and the organization of the "new education" spread, Midwestern educators quickly shaped these new colleges into useable and effective means of educating the "sons and daughters" of America's "farmers and mechanics." Administrators rejoiced in a *tabula rasa* landscape for education in the Midwest. They were not burdened by an established curriculum based on classical models or combinations of classics and science that hindered the practical education of scientists in the East. This freedom gave early leaders, institutional peculiarities, public sentiment, and regional demands the chance to influence the individual path for many of the earliest land-grant colleges in their first few decades.³⁵

³³ Charles W. Eliot, "The New Education." *The Atlantic Monthly* (February 1869): 217-220.

³⁴ Charles W. Eliot, "The New Education." *The Atlantic Monthly* (February 1869): 205.

³⁵ College histories provide the most complete, though decidedly laudatory, examinations of the early land-grant institutions, personnel, and student experiences. For the Midwest see Madison Kuhn, *Michigan State*,

Along with planning to address the local and regional needs, legislators and land-grant administrators studied numerous existing college programs and training systems as a foundation for new institutional development. Nearly every new college sent out representatives to study European schools, eastern colleges and institutes, and other agricultural or land-grant colleges. Administrators at the Iowa Agricultural College provided one of the most detailed accounts of schools visited and clear indications of what they found most compelling.

As one of the earliest and largest land-grant schools to open after the passage of the 1862 Morrill Act, Iowa's representatives not only gave detailed summaries of college curriculums and infrastructures, they also provided an exemplary model of a land-grant educational system for later educators across the country. Between 1857 and 1860, Iowa Agricultural College board members, headed by Benjamin Gue, a young state legislator, corresponded with the agricultural colleges of Michigan and New York, which by 1858 were the only two operating agricultural colleges in the United States. The board also visited the Farmers' High School of Pennsylvania and the Farmers' College and Female College near Cincinnati. Most of their observations centered on plans for a main building and how to best locate other structures such as a farmhouse, barns, and minor equipment buildings.³⁶

the First Hundred Years (Chicago: Michigan State University Press, 1955); Keith Widder, *Michigan Agricultural College: The Evolution of a Land-Grant Philosophy 1855-1925* (East Lansing: Michigan State University Press, 2005); Earle D. Ross, *A History of Iowa State College* (Ames: The Iowa State College Press, 1942); Robert Manley, *Centennial History of the University of Nebraska: Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969); Merle Curti and Vernon Carstensen, *The University of Wisconsin, 1848-1925: A History*, 2 vols. (Madison: University of Wisconsin Press, 1949); James Gray, *The University of Minnesota 1851-1951* (Minneapolis: The University of Minnesota Press, 1951); and Winton U. Solberg, *The University of Illinois, 1867-1894: An Intellectual and Cultural History* (Urbana: University of Illinois Press, 1968).

³⁶ On the size and relative influence of the early land-grant colleges see Alfred Charles True, *A History of Agricultural Education in the United States, 1785-1925* (Washington D.C.: United States Government Printing Office, 1929), 118. In the land-grant institutions opened after 1867 there were students in

Iowa's college faculty spent nearly a year traveling through the Midwest and Northeast after accepting the 1862 Morrill Act funding. Between 1867 and 1868, professors and administrators visited Michigan Agricultural College, Pennsylvania Agricultural College, Sheffield Scientific School, Massachusetts Agricultural College, and New York Agricultural College, also known as Cornell College. While at these schools, the group took note of teaching practices, program organization, and university structure. They noted that some of the colleges focused on practical agricultural training, while others had more scientific interests in mind. The growing debate between educators and the public over specialization and Justin Morrill's true intent for "agricultural and mechanic arts" instruction prompted many land-grant administrators, including Iowa's, to create a more balanced approach to "industrial education."³⁷

The Iowa representatives took particular interest in Yale's Sheffield Scientific School, which focused on science and engineering education. Sheffield's program focused on a comprehensive education, which included instruction in classical studies as well as civil engineering and mechanical arts. Sheffield educators practiced methods more advanced than an ordinary agricultural college could immediately maintain, but the Iowa committee seemed duly impressed by the organization and implementation of engineering methods Yale and Sheffield educators used.³⁸

agriculture and mechanic arts as follows: Alabama-53, Georgia-151, Kentucky-181, Mississippi-5, Oregon-50, Tennessee-37, and Virginia-122. In agricultural courses there were: Arkansas-50, Delaware-14, North Georgia-25, Illinois-87, Missouri-138, Ohio-176, and Iowa-243. For an account of the Iowa Agricultural College Board's early correspondence, travels and recommendations before 1862 see Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 202-203.

³⁷ *Second Report of the Trustees of the Iowa Agricultural College, January 27, 1868* (Des Moines: F. W. Palmer, State Printer), 52-55. Iowa State University Archives / Special Collections.

³⁸ *Second Report of the Trustees of the Iowa Agricultural College, January 27, 1868* (Des Moines: F. W. Palmer, State Printer), 55. Iowa State University Archives / Special Collections.

Part of the committee's attraction to the Yale system lay in the fact that Sheffield leaders repeatedly emphasized the position they hoped their school would occupy amongst the growing number of technical and science oriented schools. Sheffield administrators promoted high scholarship standards, focused on being a school of science rather than a practical training school, and sought a distinctive character to separate itself from other schools of science in the East so as to attract more students. Iowa's Board members felt the effort to attract students by offering unique opportunities might also work well in the sparsely populated pioneer regions of the Midwest. Also, Sheffield board members called attention to the idea that state colleges founded under the land-grant act necessarily focused on regional needs. The agricultural states of the Midwest and Great Plains gave special attention to practical agricultural training. Colleges in mining states would focus on mining engineering. In the East, educators could focus on "the instruction of engineers, mechanics, chemists, and the directors and superintendents of great manufacturing establishments." Sheffield administrators hoped to fill this niche, providing technically trained professionals who could disperse to other science oriented institutions.³⁹

³⁹ Russell Chittenden, *History of the Sheffield Scientific School of Yale University, 1846-1922*, Vol. 1 (New Haven: Yale University Press, 1928), 144. The trustees at Sheffield realized in order to develop the kind of students they desired, innovative and charismatic professors needed to organize programs of study integrating theoretical principles and practical applications. William Trowbridge, professor of dynamical engineering, felt that science and engineering educators disregarded the theoretical principles which lay at the foundation of successful implementation of practice in favor of purely practical training. Students who only operated machinery might eventually learn the finer details of the machinery, but the individual only learned a "mechanical art" and the use of tools. Those young men who obtained positions in drawing or design rooms spent their work hours tracing other's work, never learning the fundamental principles involved. On the other hand, a student who acquired thorough knowledge in principles and the rules of application prepared themselves for innumerable situations they might encounter. Principles and applications for scientific areas involving thermodynamics, mechanics, and electricity showed constantly changing situations that a student would possibly encounter, what Trowbridge called *dynamical science*. Students received instruction through lectures and "the written experiences, deductions, and classifications of the most eminent writers." See William Trowbridge, *Inaugural Address before the Sheffield Scientific*

Yale and its attached science school provided just one of the many educational models for land-grant organizers. While the Sheffield professors had organized their curricula based on a balanced combination of classical and new scientific training, newer schools focused on specialized training and coursework. Cornell College, positioned as New York State's land-grant institution, began the Sibley College of Engineering in 1885 specifically to address the mechanical and electrical engineering needs of American industry, while at the same time sorting out the conflicting notions of how to train engineers. Robert Thurston's arrival at the college in 1885 gave the new institution a vocal proponent for new professional standards in engineering education.⁴⁰

Robert Thurston's System of Engineering Education

Robert Thurston played one of the most significant roles in bringing Sibley College to the forefront of scientific engineering education. His own training mirrored that which he put into practice at the Stevens Institute of Technology from 1871 to 1885 and at Sibley from 1885 until his death in 1903. He believed that a properly trained engineer needed both a strong theoretical education acquired in the classroom and practical training on the equipment they used in the field, industrial setting, or laboratory.⁴¹

Thurston formulated his philosophy of education during his undergraduate years at Brown University. He intended to obtain his bachelor of philosophy when he entered

School of Yale College, October 5, 1870 (Philadelphia: Henry Carey Baird, Industrial Publisher, 1871), 7-8, 9-10.

⁴⁰ James Findlay, "Agency, Denominations, and the Western Colleges, 1830-1860." in *The American College in the Nineteenth Century*, ed. by Roger Geiger (Nashville: Vanderbilt University Press, 2000), 167-168.

⁴¹ William F. Durand, *Robert Henry Thurston, A Biography* (New York: The American Society of Mechanical Engineers, 1929), 95-100.

school in 1856, requiring regular coursework in history, languages, and literature. Having already obtained a strong background in practical knowledge working at his father's steam engine manufacturing company, he included classes in physical sciences, civil engineering, and mathematics with his regular coursework. When he graduated in 1859 he received both his Bachelor of Philosophy degree and a Civil Engineering degree, characterizing his education as "on the whole satisfactorily broad and liberalizing."⁴²

Following a short drafting career working for his father's company and a tour of duty with the U.S. Navy as an assistant engineer, Thurston took a position as an instructor of physics at the U.S. Naval Academy in 1866. During the late 1860s, Thurston published several articles on steam engine use and efficiency in the *Journal of the Franklin Institute*, bringing him to the attention of Dr. Henry Morton, secretary of the Franklin Institute of Science. Morton, the new president of the Stevens Institute of Technology, offered Thurston the chair of engineering. This position allowed Thurston to organize and run the mechanical engineering program however he wanted.⁴³

Thurston's own education, his experience as an instructor at the Naval Academy, and his work as a consultant for private businessmen allowed him to recognize and create an educational system based on classroom learning and laboratory experience. Thurston relied on laboratory facilities at the Naval Academy to carry on his own research, prepare materials for his lectures, and train students. He also utilized the laboratory to undertake engineering and industrial research problem solving. These two major factors, education and business concerns, guided the rest of Thurston's academic career and provided his

⁴² William F. Durand, *Robert Henry Thurston, A Biography* (New York: The American Society of Mechanical Engineers, 1929), 15-16.

⁴³ William F. Durand, *Robert Henry Thurston, A Biography* (New York: The American Society of Mechanical Engineers, 1929), 43-59.

foundation for incorporating practical training with academic learning, first at the Steven's Institute, and after 1885 at Cornell's Sibley College.⁴⁴

Many of Thurston's writings on engineering education between 1871 and 1903 provide a window into his philosophy of technical education. His written work both stimulated and reflected the professionalization of science and engineering in the late nineteenth century. He laced much of his writing with sentiments of national pride and focused repeatedly on the moral nature of technical education. He positioned American mechanics and inventors as upstanding, knowledgeable, wise individuals, keystones to the improvement and greatness of the nation as a whole. Thurston and his supporters used this ideology in the late 1890s to promote state support of education at all levels as a necessity of a strong, competent, and supportive society in the United States.

Thurston's articles on engineering education in the 1870s, written while at the Stevens Institute of Technology, primarily called for specialized teaching apparatus for chemistry and science, more technical universities, and promoted his ideas on how those schools should be set up. He provided specific details on engineering programs, instructor requirements, and necessary equipment. He wanted to promote the establishment of specialized technical schools while simultaneously cajoling larger institutions to begin setting up scientific and engineering programs and departments.⁴⁵

Thurston, like many of the leading educators of the late-nineteenth century, believed that technical specialists needed to properly combine scientific and experimental knowledge, mechanical ability, and engineering expertise. But unlike many educators at

⁴⁴ William F. Durand, *Robert Henry Thurston, A Biography* (New York: The American Society of Mechanical Engineers, 1929), 67-69.

⁴⁵ Robert Thurston, "Apparatus Illustrating Mechanical Principles." *Journal of the Franklin Institute*, Vol. 92 (1871): 192-195; and Robert Thurston, "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872): 17-25.

the new land-grant universities, Thurston separated the function of science and engineering. He noted that men of science should answer questions about scientific principles, while engineers should investigate questions of construction, efficiency, and application of scientific principles.⁴⁶

To accommodate the interconnections of science and engineering, Thurston desired technical and industrial schools that could train young men in the methods of both scientific principles and engineering applications. He specifically praised European models of specialized education, but the emergence of land-grant colleges in the American heartland, most of which incorporated methods of both European and American technical education developments, entered into his rhetoric in only a limited fashion.

Faculty at Rensselaer Polytechnic Institute began a course in mechanical engineering in 1862, but records show no students ever took the course and no one graduated with the degree.⁴⁷ Before Robert Thurston arrived in 1885, Cornell University administrators struggled to properly define how technical education should be conveyed in the classroom. And the Naval Academy focused exclusively on scientific curricula until 1871, at which point Navy veterans Thurston and Erasmus Darwin Leavitt began introducing shop training so that naval engineers could properly build and maintain the new steam engines of the U.S. Navy.⁴⁸

Thurston's technical education philosophy built upon his own experience working on steam ships during and after the Civil War. By the early 1870s, he recognized the

⁴⁶ Robert Thurston, "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872): 17, 22-23.

⁴⁷ Palmer C. Ricketts, *History of Rensselaer Polytechnic Institute, 1824-1914* (New York: John Wiley & Sons, 1914), 105-110.

⁴⁸ Monte A. Calvert, *The Mechanical Engineer in America, 1830-1910* (Baltimore: The Johns Hopkins Press, 1967), 44-45.

need for two fundamental accoutrements for the engineering field in order for it to become a full fledged profession. First, engineers needed a dedicated method of publication that could provide detailed and specific knowledge for their field. Thurston felt that much of the privately and publicly supported scientific research went unpublished or remained inaccessible to engineers who could make proper use of the data. Second, Thurston called for an institution devoted to the problems and investigations for which engineers were particularly suited. Though he recognized and promoted many of the “unexplored paths” that needed thorough investigation, he warned that most engineers did not have the proper practical training to do the work.⁴⁹

Agricultural scientists focused on many of the same issues in the 1870s and 1880s, providing today’s historians with a parallel case study in the development of a scientific institution to develop and promote scientific ideas and practices for the general public. In his study of the professionalization of agricultural sciences and the development of agricultural experiment stations following the passage of the Hatch Act in 1887, historian Alan Marcus found that farmers blamed land-grant college personnel for inadequate training in farming techniques and quickly became dissatisfied with courses and faculty. Even the farmers located near land-grant colleges remained loyal to their traditional systems of farming and only with great reluctance adopted any new ideas brought in from outside the local region, thus diminishing the immediate effect of agricultural modernization in the West.⁵⁰

⁴⁹ Robert Thurston, “On the Necessity of a Mechanical Laboratory; its province and its method.” *Journal of the Franklin Institute*, Vol. 100 (1875): 409-411.

⁵⁰ Alan Marcus, “The Ivory Silo: Farmer-Agricultural College Tensions in the 1870s and 1880s.” *Agricultural History*, Vol. 60 (Spring 1986): 23-25.

Educational leaders believed that developing the idea of professional status for farmers and mechanics, as well as promoting the college's role in advancing agricultural science would eventually overcome the farmers' stubbornness. Marcus noted college officials insisted that if they could successfully incorporate agricultural science into the curriculum, then students would become better scientific investigators. This implementation depended on the systemization of not only scientific curricula, but also farming techniques. By systematizing agricultural science and the overall curricula students received, agricultural college faculty promoted themselves as developers of professional farmers. In the 1870s and 1880s, Thurston's writings also conveyed a wish for scientists and engineers to apply this kind of ideology to technical instruction, including theoretical and practical instruction, through engineering experiment stations.⁵¹

Historians of agriculture and science have found that the dramatic increase in need for technical expertise at the experiment stations improved the prospects of students educated at agricultural schools and also carried the idea of professional status to the farmers and agricultural community. Faculty, staff, and students found a direct route from the college course work to the needs of the farmers by developing scientific soil studies, fertilizer processes, and crop developments, and implementing new technologies on the farm and in the wood and metal workshops. College faculty and graduates encouraged professional farming through what they portrayed as professional practices.⁵²

Many historical studies conclude that the lack of qualified instructors made farmers indifferent towards early agricultural schools and skeptical about the practicality

⁵¹ Alan I Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890* (Ames: Iowa State University Press, 1985), 32-34.

⁵² David B. Danbom, "The Agricultural Experiment Station and Professionalization: Scientists' Goals for Agriculture." *Agricultural History*, Vol. 60 (Spring 1986): 246-247, 255.

of scientific methods. Farmers believed that they could teach their sons everything they needed to know, and that scientific educators at the colleges remained too concerned with their own investigations instead of providing useful knowledge for the local farmer. However, as the experiment stations grew, scientists and staff at the stations and colleges began to provide directly applicable methods of planting, fertilizing, and breeding that farmers readily adopted into their farming practices. Even though the growth of science appeared to deter farmers from trusting the college administration and faculty (indeed, many young students turned away from farming in favor of more “scientific” endeavors) the development of experiment stations and the professional status that science conferred upon agricultural education slowly won over the large majority of farmers.⁵³

In many ways, Thurston had already laid out the groundwork for similar steps toward creating engineering experiment stations in the mid-1870s. First, he argued, the researcher needed to know the basis of the investigation. Scientific staff had to formulate precise questions so that they could perform intelligent work to answer them. Investigators needed narrowly defined questions in order to keep the answers as precise as possible. Second, staff had to collect and combine the results into a clear hypothesis and set of conclusions. A cross-disciplinary working combination of chemists, physicists, and mechanics was the only sure way to fully solve the problem and provide a mathematical expression for the answer to the question. Third, researchers needed to look at past research and information so that previous experiments and data could be included in the analysis. Fourth, after the investigators properly understood the questions

⁵³ Richard Bradfield, “The Sciences, Pure and Applied, in the First Century of the Land Grant Institutions.” *Science Education*, Vol. 46 (April 1962): 240-241; Paul E. Waggoner, “Research and Education in American Agriculture.” *Agricultural History*, Vol. 50 (January 1976): 243; and Frederick B. Mumford, *The Land Grant College Movement*, Bulletin 419 (Columbia: University of Missouri Press, July 1940), 32.

and had gathered the necessary knowledge that addressed the questions, they could formulate and undertake new investigations. Fifth, scientists had to publish their methods of collection and present their data and results. Sixth, along with publication, scientists had to make deductions based on the results aimed at furthering scientific knowledge and justifying their work in the field.⁵⁴

Thurston also addressed the desired location for establishing new mechanical laboratories that could carry out the described procedures. He insisted that researchers had to locate the institutions near the people and places that were interested in particular kinds of work. Thurston promoted the idea that it would be extremely beneficial if station organizers situated the mechanical laboratories near an established technical institution with a good reputation so scientists and technicians could begin work under an established and respected institutional framework.

The size of the experimental laboratory would depend on the management of the institution, Thurston wrote. Good management would lead to a larger facility and more respected research endeavors. The needs and experiments of the laboratory would dictate the equipment needed. Most facilities would require machines for testing construction material qualities. Thurston listed dynamometric apparatus, lubricant testing equipment, steam engine indicators, calorimeters, thermometers, and other basic types of diagnostic equipment as just a few of the necessary pieces of laboratory equipment. He also believed that specially designed and adapted equipment would become necessary as laboratories began their work and new fields of research emerged.⁵⁵

⁵⁴ Robert Thurston, "On the Necessity of a Mechanical Laboratory: its province and its method." *Journal of the Franklin Institute*, Vol. 100 (1875): 413-414.

⁵⁵ Robert Thurston, "On the Necessity of a Mechanical Laboratory: its province and its method." *Journal of the Franklin Institute*, Vol. 100 (1875): 415-416.

The desirable characteristics of personnel for the new mechanical laboratories seemed fairly obvious to Thurston. Only a director trained in science and engineering could provide proper and informed management. Instructors needed high quality and intensive training in both science and engineering so that they could appeal to different social, working, and intellectual levels of students that would attend the school. Mechanics would be necessary to maintain and repair the equipment that was vital to the operation of the institution.⁵⁶

With his background in education and practical application of engineering knowledge, Thurston viewed educators as having two distinct responsibilities. First, they needed to “cultivate the individual” by providing intellectual growth and knowledge. Second, the educator had to provide technical knowledge so that the student could pursue work in the increasingly complex world of the late-nineteenth century. The technical training and practical laboratory experience Thurston proposed combined theory with practice and “provided individuals with the best opportunity for beneficial and productive careers in society.”⁵⁷

As early as the 1860s, but more distinctly by the 1880s, Thurston foresaw the expensive nature of the technical schools, laboratories, and experiment stations he proposed. He recognized that wealthy individuals and businesses in American society would have to provide much of the capital for these educational and research oriented ventures. The American democratic government had maneuvered itself out of directly funding technical schools, as the European governments did, by supplying saleable

⁵⁶ Robert Thurston, “On the Necessity of a Mechanical Laboratory: its province and its method.” *Journal of the Franklin Institute*, Vol. 100 (1875): 416.

⁵⁷ Robert Thurston, “Technical Training Considered as Part of a ‘Complete and Generous Education.’”, *Scientific American Supplement*, Vol. 24 (1887): 9614.

federal lands with the 1862 Morrill Land-Grant Act, but Congress did not provide a clear and concise method of education.⁵⁸

The land-grant college administrators, though initially adopting a balanced agricultural and engineering foundation, had moved almost exclusively into agricultural endeavors following the 1887 Hatch Act for agricultural experiment stations. College leaders went where the money lay, and engineering laboratories simply didn't have the federal support that agricultural science enjoyed in the late-nineteenth century.⁵⁹

Robert Thurston had a good idea where the money did lie for the development of engineers and the various fields they worked in. Industrialists had expanded into every manufacturing field available in the late-nineteenth century, and Thurston had a finger in many of them. In his annual address to the American Society of Mechanical Engineers in 1881, Thurston spoke in detail about iron and steel processing, materials strength testing and construction, textile production, railroad organization, steam engines and the science of thermodynamics, electrical engineering, and aeronautics. By describing the advancements in these various areas, Thurston found the common thread in the importance of the laboratory and the trained individual who knowledgeably and efficiently ran the necessary investigations.⁶⁰

⁵⁸ Robert Thurston, "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872): 17.

⁵⁹ Alan I Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890* (Ames: Iowa State University Press, 1985): 217-219. Further discussion of engineering experiment stations can be found in Edwin T. Layton, "Mirror Image Twins: The Communities of Science and Technology in 19th Century America," *Technology and Culture*, Vol. 12, No. 4 (October 1971): 562-580; Bruce Seely, "Research Engineering and Science in American Engineering Colleges, 1900-1960," *Technology and Culture*, Vol. 34, No. 2 (April 1993): 344-386; and Daniel Kevles, "Federal Legislation for Engineering Experiment Stations: The Episode of World War I," *Technology and Culture*, Vol. 12, No. 2 (April 1971): 182-189.

⁶⁰ Robert Thurston, "Our Progress in Mechanical Engineering: The President's Annual Address." *Transactions, American Society of Mechanical Engineers*, Vol. 2 (1881): 415-422.

Thurston insisted on elevating the “Universities of Science and Art” to the same level as the older schools of the east coast in terms of both prestige and ability to educate and train professionals. He believed that mechanical engineering had to combine science in the form of experimental knowledge with mechanical ability attained through hands-on experience. Additionally, while Thurston supported the land-grant system that created state schools of science, he wanted to coordinate all the local trade and state scientific schools with a national technical university that administered the training and placement of scientists and engineers.⁶¹

During the 1880s, Thurston framed his ideas for organizing the training of engineers within the concept of “new education.” Thurston borrowed the organizational ideas of Gilman and Eliot to propose a vast network of technical schools that could share the monetary and laboratory resources in the effort to promote the engineering sciences. Thurston did not limit his system to knowledge and method. He maintained a consistent approach to education and mechanical training which directly supported the manufacturing and industrial pursuits of the nation. In his view, the only way for American business to progress and challenge European industrialization was if schools of science improved their educational methods and laboratory efforts.⁶²

⁶¹ Robert Thurston, “Our Progress in Mechanical Engineering: The President’s Annual Address.” *Transactions, American Society of Mechanical Engineers*, Vol. 2 (1881): 422-442. Thurston spoke on nearly the same topics and in the same fashion two years later in his third and final annual address to ASME. See Robert Thurston, “The Mechanical Engineer – His Work and His Policy: The President’s Annual Address.” *Transactions, American Society of Mechanical Engineers*, Vol. 4 (1883): 75-105.

⁶² Numerous Thurston articles and addresses touch on the subject of “new education” and the instruction of mechanical engineers, particularly between the mid-1880s and early 1890s, which coincided with the end of his tenure of president of ASME and his involvement in SPEE. For instance, see R. H. Thurston, “Instruction in Mechanical Engineering.” *Scientific American Supplement*, No. 433 (19 April 1884): 6904-6905; Robert Thurston, “The Mission of Science.” *Proceedings, American Association for the Advancement of Science, Section D*, Vol. 33 (1884): 227-253; R. H. Thurston, “Education of the American Citizen.” *Scientific American Supplement*, No. 524 Vol. 21 (16 January 1886): 8368-8370; R. H. Thurston, “On the Education of Engineers.” *Scientific American Supplement*, Vol. 22, No. 559 (18 September 1886): 8919-8921; R. H. Thurston, “Technical Training Considered as a Part of a Complete and Generous

The growth of higher education at every level by the late 1880s and early 1890s prompted many educators and intellectuals to begin discussing the possibilities for improved and standardized methods of instruction and support. Between 1879 and 1889, 444 institutions of higher learning enrolled almost 39,000 students. The U.S. Bureau of Education, created in 1866, classified eighty of these schools as science and technology oriented, accounting for over 6,600 total students. By 1890 this number had increased to over 7,500.⁶³

Robert Thurston carried the statistical study of technical education even further in 1889 by closely examining the science and engineering schools in the United States, their location, and the number of students graduating. New England States had 11 schools with 161 graduates and 20 Middle State schools graduated 255 students. 100 students graduated from 28 Southern schools, while 29 North Central States had 184 graduates and only 6 Pacific State schools produced 24 graduates. He noted that the Bureau of Education reported 724 total students receiving specialized engineering degrees in 1889, and 623 students received science degrees from all colleges registered with the Bureau.⁶⁴

These numbers prompted Thurston to write extensively on the need for state supported schools, education supporting the nation, and education preparing individuals to become part of the system of the social economy. He stressed that the states and the nation had to adequately prepare citizens to provide for the nation as a whole. The states

Education.” *Scientific American Supplement*, Vol. 24, No. 602 (16 July 1887): 9614-9616; R. H. Thurston, “Science and Practice.” *The Crank*, Vol. 5 (February 1891): 9; and R. H. Thurston, “The Demands of the State.” *The Crank*, Vol. 6 (1892): 337-365.

⁶³ Roger Geiger, “The Era of Multipurpose Colleges in American Higher Education.” in *The American College in the Nineteenth Century*, ed. by Roger Geiger (Nashville: Vanderbilt University Press, 2000): 130.

⁶⁴ Robert Thurston, “Technical Education in the United States: Its Social, Industrial, and Economic Relations to our Progress.” *Transactions, American Society of Mechanical Engineers*, Vol. 14 (1893): 950-955.

also needed to support regionally-targeted educational endeavor so that citizens could properly contribute to the regional economy. Thurston considered technical training a vital piece to this undertaking since technical schools produced the most versatile workers and best prepared professionals for developing and advancing the nation.⁶⁵

To implement such a vision, Thurston garnered support through his numerous committee networks, such as the Iron and Steel Board and the American Society for Mechanical Engineers. In 1893 he proposed an interconnected system of technical instruction for all science and engineering programs in the United States. He felt that better instruction in experimental engineering would lead to greater contributions in applied science, which would do more for society than anything else put forth by educational institutions.⁶⁶

In 1893, at the World's Columbian Exposition in Chicago, Thurston and his colleagues created the Society for the Promotion of Engineering Education. Thurston outlined his methods and goals for the organization in a lengthy article published in the *Transactions of the American Society of Mechanical Engineers*. Though largely an elaboration on his own experiences, course structure, and curriculum at Cornell's Sibley College, Thurston had formulated a complete system of education for mechanical engineers. He praised the triumph of his methods not only as producing successful engineers, but also providing the primary foundation for the emergence of the

⁶⁵ Robert Thurston, "The New Education and the New Civilization – Their Utility." *Scientific American Supplement*, Vol. 34 (1892): 13825-13826.

⁶⁶ Robert Thurston, "The Needs and Opportunities of a Great Technical College." *Scientific American Supplement*, Vol. 36 (1893): 14587.

engineering educator as a distinct type of professional separate from business and industry.⁶⁷

Using Thurston's guiding framework, men teaching civil, mechanical, mining, and electrical engineering formed a powerful group that by the late 1890s controlled curriculum, admission standards, laboratory practices, and even textbook use. Although SPEE maintained close relationships with the major engineering societies, such as the American Society of Mechanical Engineers, the American Society of Electrical Engineers, and the American Society of Civil Engineers, the organization's leaders and members came out of engineering education rather than industry or business.⁶⁸

In laying out his ideas for state supported schools, Thurston combined the advantages of the larger, well-established technical schools of the East with the state supported, practical objectives of the Midwest and Western land-grant schools. Thurston judged that large schools of engineering best addressed applied science problems by incorporating them into their laboratory work. These schools already had substantial amounts of equipment, significant laboratory space, and interconnected coursework. Larger schools also provided the best opportunity for fellowships and scholarships for talented men from the lower class to enter into the engineering field.⁶⁹

Establishing laboratory work was a start, but school leaders also needed to develop instruction in methodology and practice. Thurston and his supporters from

⁶⁷ Robert Thurston, "Technical Education in the United States." *Transactions, American Society of Mechanical Engineers*, Vol. 14 (1893): 855-877.

⁶⁸ Monte Calvert, *The Mechanical Engineer in America, 1830-1910* (Baltimore: The Johns Hopkins Press, 1967): 57-58. Historians have yet to write a full-length history of SPEE. Calvert and other historians who have written about the early period of engineering education and professionalization briefly mention SPEE, but do not offer a detailed history of who was involved, how they operated, or what their long term influence might have been.

⁶⁹ Robert Thurston, "The Needs and Opportunities of a Great Technical College." *Scientific American Supplement*, Vol. 36 (1893): 14587.

professional organizations like the American Society for Mechanical Engineers, the American Association for the Advancement of Science, and the Society for the Promotion of Engineering Education realized that changing requirements in industry and business would necessitate individual schools and programs to adjust accordingly. Instructors in each state would need to specialize and perform independent research, and the land-grant schools were particularly well-suited for such an endeavor.⁷⁰

To coordinate the state run research, Thurston advanced his ideas for a national university system. State leaders would run their own schools, but a national system could coordinate the various research projects and provide for the education of future faculty to operate the widely dispersed laboratory facilities. The individual technical schools would lose some of their autonomy, but the gains in technical education and the promotion of engineering would far outweigh the loss.⁷¹

Thurston played on the idea of national progress and America's technical lead over Europe in his editorial to the *New York Daily Tribune* in 1897. Thurston had modeled much of his ideal national engineering system on the technical school systems established in Germany, France, and England. He believed that the European systems were superior in terms of knowledge and science instruction, but they simply didn't have

⁷⁰ Robert Thurston, "Industrial Education." *New York Daily Tribune*, 14 April 1897: 14. For a detailed study of the origins and specific activities of professional engineering societies see Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Baltimore: The Johns Hopkins University Press, 1986). In particular, Layton's bibliographic essay provides an extensive list of engineering society studies and histories. Thurston's role in the organization and early history of the American Society of Mechanical Engineers is analyzed in Bruce Sinclair, *A Centennial History of The American Society of Mechanical Engineers, 1880-1980* (Toronto: University of Toronto Press, 1980). The only history of the Society for Promoting Engineering Education, which became the American Society for Engineering Education in 1946, is Terry Reynolds and Bruce Seely, "Striving for Balance: A Hundred Years of the American Society for Engineering Education." *Journal of Engineering Education*, Vol. 82 (July 1993): 136-151. For an analysis of the Society for Promoting Engineering Education as it related to industry in the early twentieth century see David F. Noble, *America By Design: Science, Technology and the Rise of Corporate Capitalism* (New York: Oxford University Press, 1977).

⁷¹ Robert Thurston, "Engineering a Learned Profession." *Scientific American Supplement*, Vol. 38 (1894): 15469.

the equipment or resources to fully implement the necessary training in practical applications. Thurston called on the states to redouble their efforts to promote and advance technical training so that the United States would not lose the lead in scientific efforts. Engineers recognized the Morrill Land-Grant Act, the numerous land-grant colleges, and industry as vital to technical education and engineering, however state governments had to accept a larger share of the financial burden. Thurston and his supporters placed the success of the national university system on the strength of state colleges and experiment stations, which could only remain strong if the individual states fully supported them.⁷²

Thurston did not provide the only plea for a national system. Editors of the journal *Science* also advocated for a national university which provided for the progress of education and science. They acknowledged the benefits and attainments of new schools like Johns Hopkins, Chicago and Stanford. However, these schools operated independently. A national university would benefit all of American society. The editor did consider three major objections: cost, political meddling, and interference with other institutions. The author cited cost as less than the public assumed, and negligible next to European ascension in science and technology development. The Commissioner of Education and regents of the Smithsonian Institution could govern the university. And since the school would act as the head of the American educational system, it would not interfere with other institutions any more than they interfered with each other.⁷³

Between 1898 and 1902, numerous other college leaders and professors addressed the question of the relation between the state and higher education. Prior to the later

⁷² Robert Thurston, "Industrial Education." *New York Daily Tribune*, 14 April 1897: 14.

⁷³ "A National University." *Science*, ns, Vol. 5, No. 110 (5 Feb. 1897): 197-199. Also see Chas. W. Dabney, "The National University." *Science*, ns, Vol. 5, No. 114 (5 Mar. 1897): 378-384.

1890s, questioners of state supported education focused on denominational affiliations and the separation of church and state along with the necessities of curriculum change and the practicality of instruction.⁷⁴ However, by 1900, administrators and professors saw an opportunity to advance the status of their institutions and place their work at the forefront of national agency.

H.S. Pritchett, president of the Massachusetts Institute of Technology, saw that the state and national governments relied increasingly on educated men for expert advice and assistance. Knowing that government required a larger pool of trained, scientific professionals, Pritchett applauded the efforts of the state to support and enhance higher education and scientific investigation. But he also pleaded with government officials to continue supporting public education and scientific training so that the individual could realize their full potential and contribute successfully to American society.⁷⁵

Ira O. Baker, president of the Society for Promoting Engineering Education in 1900, focused on the state financial support of students and their obligatory contributions to the state following graduation. Baker cited numerous statistics from the Bureau of Education to support his claim that the progressive improvement in American society directly correlated to the advanced training and skill of American engineers, trained at state supported schools. The introduction of laboratory methods, advanced by Robert Thurston in the 1870s, and curriculum developments witnessed following the organization of the Society for Promoting Engineering Education contributed

⁷⁴ N.H. Winchell, "The State and Higher Education." *Science*, ns, Vol. 2, No. 62 (3 Sept. 1881): 413-416.

⁷⁵ H.S. Pritchett, "The Relation of Education Men to the State." *Science*, ns, Vol. 12, No. 305 (2 Nov. 1900): 658-660.

immediately to scientists and engineers surpassing their peers in Europe and enhancing the education and training of their followers.⁷⁶

Within a year, Charles D. Walcott and R. H. Jesse, both professors of engineering, further addressed the relation of the national government to higher education and research. Walcott and Jesse pointed out that even though the national government had no power to appropriate money for educational purposes it had done so since the colonial period through land grants and other forms of aid. While the states controlled the operation of the institutions in America, their survival and success depended on national support. Both men concluded by stressing that the individuals who obtained training at state-supported schools had an obligation to contribute to the state and national well-being of the public.⁷⁷

The importance of state support and national organization played directly into the national pride and progressivism that Thurston displayed in his later publications. He believed states had to take it upon themselves to support and promote technical schools. Land-grant administrators and professors accomplished this in the Midwest, West, and South where land-grant schools became major science and technology institutions by the late-nineteenth century. Though the East housed some of the most prestigious institutions, Harvard, Yale, and Cornell for example, they lagged behind in many ways because of their private funding and established traditions. Attached schools such as Sheffield Scientific Institute and Sibley College, along with the independent Stevens Institute of Technology provided outstanding centers of scientific learning and practical

⁷⁶ Ira O. Baker, "Engineering Education in the United States at the End of the Century." *Science*, ns, Vol. 12, No. 305 (2 Nov. 1900): 666-674.

⁷⁷ Charles D. Walcott, "Relations of the National Government to Higher Education and Research." *Science*, ns, Vol. 13, No. 339 (28 June 1901): 1001-1015. R. H. Jesse, "The Function of the State University." *Science*, ns, Vol. 14, No. 343 (26 July 1901): 138-143.

training, but they relied on philanthropists and private endowments to sustain professors and their research.⁷⁸

College leaders like Charles Eliot at Harvard University, and Daniel Coit Gilman at Yale, the University of California, and then Johns Hopkins University also contributed to the development of a new, scientific education aimed at the agricultural and industrial classes. Their support of classroom learning, practical training, and professional laboratory experience seemed combative and disruptive towards the established classical college systems in the 1870s and 1880s. However, their approach provided other institutions of higher learning, including Midwest land-grant colleges, with models and lessons for implementing educational techniques and developing well-trained scientists and engineers.

While Daniel Coit Gilman and Charles Eliot formed broad philosophies of education that they then implemented at Johns Hopkins and Harvard University in the late nineteenth century, Robert Thurston, as a practitioner and leader of engineering education, provided a guide for much of the specialized engineering curricula and laboratory changes that took place before 1900 at land-grant schools across the nation. His nearly 2000 students went on to fill educational and industrial positions across the nation, especially at Midwestern land-grant colleges looking for innovative and well-trained professors. Thurston also worked to expand his own professional network. His publications reached administrators, professors, and businessmen alike. Through his teaching, writing, and leadership of the American Society of Mechanical Engineers, and

⁷⁸ Robert Thurston, "Technical Education in the United States: Its Social, Industrial, and Economic Relations to our Progress." *Transactions of the American Society of Mechanical Engineers*, Vol. 14 (1893): 921-922.

later the Society for Promoting Engineering Education, Robert Thurston played a significant role in the professionalization of science and engineering education.

Land-grant college administrators and professors at places like Michigan and Iowa also promoted the professional status of their graduates by constructing ambitious philosophies of scientific learning and liberal education based on the legislative mandate of the 1862 Morrill Act. The continued growth and specialization of higher education, the expansion of manufacturing, and the organization of experiment stations and professional engineering societies allowed education experts to firmly assert the need and justification for highly trained specialists and professional engineers, as the nineteenth-century came to a close.

CHAPTER 3. ADVANCING KNOWLEDGE, TRANSFORMING LIVES– ENGINEERING AT THE MICHIGAN AGRICULTURAL COLLEGE BEFORE 1893¹

Early engineering education in the state of Michigan depended on a mixture of frontier identity, modernization needs (or perceptions), and educational philosophy and emphasis. Residents of Michigan held to a firm belief in self-reliance for much of the nineteenth century, fundamentally shaping the kind of education and training they wished their children to receive at schools and colleges. As the state industrialized and built up its infrastructure, businessmen and educators alike recognized a growing need to supply locally trained individuals who could perform the necessary organization, management, and oversight of technical operations. People in Michigan looked to their educational systems to support their independent identity while at the same time modernizing the state. Professors and administrators at the Agricultural College², acting under the direction of the 1862 Morrill Land-Grant Act, constructed a system of education that aimed to address the state's needs and desires.

Immigrants and pioneers who came to the Michigan region entered a frontier economy that strived for advancement and struggled with the limitations of geography and transportation. Prior to the 1840s, Michigan settlers entered a frontier landscape sparsely inhabited by Native Americans and French trappers. Early pioneers typically arrived with

¹ Michigan State University continues to use this as the official motto of the University. It's origins can not be verified at this time, however.

² The Agricultural College went through six official name changes during its history: 1855-1861, Agricultural College of the State of Michigan; 1861-1909, The State Agricultural College; 1909-1925, Michigan Agricultural College; 1925-1955, Michigan State College of Agriculture and Applied Science; 1955-1964, Michigan State University of Agriculture and Applied Science; 1964-present, Michigan State University. The name Michigan Agricultural College was commonly used long before it became the official name. I will use Michigan Agricultural College, or more simply Agricultural College throughout this chapter. The preceding information was provided by Keith R. Widder. *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), xxi.

large kinship groups that could rely on one another to establish and expand family farms and businesses. These early settlers, comprised mostly of northeastern farmers and European immigrants, also relied on communities of religious supporters who had begun to move west during the religious upheavals of the Second Great Awakening. Early Michigan pioneers had to rely on themselves or a local community for any skilled work needed for the farm or business.³

By the 1840s, Michigan settlers had built the agricultural and industrial base of the region on a philosophy of self-sufficiency and stability. Farmers adapted production methods based on restricted external trade and created an economic system based on need rather than price. Some increased the amount of subsistence crops, such as corn and tuberous vegetables that had an early harvest and could be processed locally. Others diversified their agricultural production by including wheat, corn, vegetables, and fruits to meet wider demands and insure against potential crop failure. This diversification also involved producing specialized items such as brooms and tools, and providing repair services for regional neighbors. This system of isolated trade and a philosophy of production based on household use provided stability for frontier farmers and allowed industrial production to adapt to local economic conditions.⁴

With a regionalized economy firmly in place by the 1840s, the development of roads and other infrastructure became a system of inward focused networks that supported settlement but hindered any kind of large-scale export efforts. Agricultural and other rural industries in the southern areas of Michigan expanded to include the production of maple sugar, potash, and shingle making in the 1840s and 1850s. Immigrants and settlers to

³ Kenneth E. Lewis. *West to Far Michigan, Settling the Lower Peninsula, 1815-1860* (East Lansing: Michigan State University Press, 2002), 127-152.

⁴ Kenneth E. Lewis. *West to Far Michigan, Settling the Lower Peninsula, 1815-1860* (East Lansing: Michigan State University Press, 2002), 167-169. On the development of internal improvements in the state of Michigan after 1837 see Robert J. Parks, *Democracy's Railroads, Public Enterprise in Jacksonian Michigan* (Port Washington, NY: Kennikat Press, 1972).

northern areas of the state worked primarily in the mining and lumber industries. All of these endeavors required skilled managers and engineers who could organize and oversee the technical work involved in road and railroad construction, mine construction, and building construction related to industrial development.⁵

The residents of Michigan, dealing with limiting infrastructure networks and nonexistent or distant production of industrial goods, coupled with a long history of self-reliance and self-sufficiency, realized they needed to develop an educational system which could address these concerns. Public instruction for all ages had a history as long as the territory itself, primarily relying on a classical system of education found in the east. But these established systems did not train young Michigan workers to engage in the work required to build and modernize the state itself. By the late 1840s and early 1850s, educators began advancing the idea that students needed more science and applied instruction in order to improve agricultural and industrial efforts within the state.⁶

While the University of Michigan, in Ann Arbor, held its opening ceremonies in 1841, the initial direction of the school failed to adequately address the technical needs of the state. Over a decade of poor leadership, dissention, and a fundamental lack of institutional direction plagued the University from its opening day. Organizers initially included a provision for civil engineering instruction, but the administration did not hire any qualified faculty to cover

⁵ On migration and immigration into the southern part of Michigan, along with related agricultural and industrial developments see: Kenneth E. Lewis, *West to Far Michigan, Settling the Lower Peninsula, 1815-1860* (East Lansing: Michigan State University Press, 2002), 163, 169. For information on the northern industries of Michigan and wide-scale transportation construction see Willis F. Dunbar. *Michigan, A History of the Wolverine State*, 3rd ed., ed. by George S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 249-262. For a general examination of socioeconomic change in the early decades of the state of Michigan see Martin J. Hershock, *The Paradox of Progress: Economic Change, Individual Enterprise, and Political Culture in Michigan, 1837-1878* (Athens: Ohio University Press, 2003).

⁶ Willis F. Dunbar. *Michigan, A History of the Wolverine State*, 3rd ed., ed. by George S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 279-296. Further developments on early Michigan education efforts that led to the creation of the University of Michigan can be found in Howard Peckham, *The Making of The University of Michigan, 1817-1967* (Ann Arbor: The University of Michigan Press, 1967), 1-30.

the courses until the 1860s. In 1850, Michigan held a constitutional convention, which opened the door for agricultural education in the state, and also allowed for the reorganization of the University.⁷

Henry Tappan, who became president of the University of Michigan in the 1850s, pioneered the application of German practical education in the United States. Charles Eliot at Harvard University and Daniel Coit Gilman at Johns Hopkins University and later the University of California, had already started leading the eastern elites towards a more democratic educational system based on educating a wider array of the public. But Tappan planted the idea of instruction specifically geared towards the working classes in the upper-Midwest.⁸

Tappan's vision of a Germanic style "practical" center of education focused on the combination of thought and work. In an address in 1853, he discussed his travels in Europe and Prussia and the types of practical education they received there. He noted that Provincial Artizans schools in Prussia provided the preparatory instruction for most students before they could enter the Royal Artizans School. In the provinces, students studied mathematics up to calculus, natural science, and drawing, and worked at least a year in a mechanic's or engineer's shop. Once they entered the Royal Artizans school, students concentrated on

⁷ Howard Peckham. *The Making of The University of Michigan, 1817-1967*. (Ann Arbor: The University of Michigan Press, 1967), 1-30. See also Willis F. Dunbar. *Michigan, A History of the Wolverine State*. 3rd edition edited by George S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 288-290.

⁸ For Eliot's and Gilman's established views on higher education see Charles Eliot, "The New Education: Its Organization." *The Atlantic Monthly*, February-March 1869: 203-220 and 358-367; and Daniel Coit Gilman, "Our National Schools of Science," *North American Review* (October 1867): 498-499. See also Henry James, *Charles W. Eliot: President of Harvard University, 1869-1909*, 2 vols. (Boston: Houghton Mifflin Company, 1930); Hugh Hawkins, *Between Harvard and America: The Educational Leadership of Charles W. Eliot* (New York: Oxford University Press, 1972), Samuel Eliot Morison, *Three Centuries of Harvard, 1636-1936* (Cambridge: Harvard University Press, 1936), Fabian Franklin, *The Life of Daniel Coit Gilman* (New York: Dodd, Mead & Company, 1910), and Hugh Hawkins, *Pioneer: A History of The Johns Hopkins University, 1874-1889* (Ithaca: Cornell University Press, 1960). For a comprehensive general history of the American university see Laurence R. Veysey, *The Emergence of the American University* (Chicago: The University of Chicago Press, 1965).

chemistry, architecture, or engineering. During the entire process, specialized teachers provided instruction and oversaw the practical shop-work undertaken by students.⁹

Drawing upon his observations in Prussia, Tappan wanted to make the University of Michigan as useful to the citizens of the state as the Artizans schools were for Prussians. This meant having an overarching system of instruction unified in concept and delivery. Tappan believed that there should be one school in Michigan, which addressed all the concerns of the people. He envisioned the university offering specific courses for specific businesses and endeavors, whether literary and scientific or industrial and agricultural. Splitting up the school into smaller pieces would prohibit development and advancement of industry and business for the state, funds would be scattered and ill-used, and competition between schools would fracture the system of instruction. Tappan noted that the majority of people lived in or near Detroit, and the University already had the apparatus, books, and professors in place, so it just made sense to have agricultural and industrial schools at the University.¹⁰

Tappan maintained a broad vision for the benefits of the university, including communities, infrastructure, and businesses in his plan to connect thought and work in all fields. He emphasized that people in cities, towns, and on farms relied on each other, just as the industrial laborers and farmers relied on one another to grow and prosper. Cities relied on smaller “satellite” towns to support manufacturing and commerce. Farming communities surrounded the “satellite” towns to provide food. And the cities and towns provided the tools and implements to make farming more productive. But in order to create better businessman, engineers, and farmers, Tappan stressed qualified individuals and groups needed to transmit

⁹ Dr. H. P. Tappan, *Address to Michigan Agricultural Society, September 1853*: 13-14. UA 17.107 Kuhn Collection, Box 1143R, Folder 67. Michigan State University Archives and Historical Collections.

¹⁰ Dr. H. P. Tappan, *Address to Michigan Agricultural Society, September 1853*: 22-24. UA 17.107 Kuhn Collection, Box 1143R, Folder 67. Michigan State University Archives and Historical Collections.

the experiences and experiments of individuals to the wider community. Tappan wholeheartedly believed in the idea that industrial prosperity kept pace with intellectual development; the thinking man provided the most for society, while the laboring man kept the processes going.¹¹

Despite Tappan's advocacy of a system of education that benefited all levels of society through the combination of ideas and work, his intentions did not meet public demands. Tappan's idea that educated men should be aristocrats, to him meaning the wisest and best men, did not sit well with Michigan's working class, which viewed themselves as pioneering frontiersmen who valued equality and hard work above all else. Disagreement over Tappan's leadership objectives, a general loathing of his haughty and entitled nature, and a perceived lack of "practical" studies at the university led to public cries for change to include more agricultural and technical training that directly benefited the working classes.¹²

In 1850, state legislators of Michigan established their own mandate for agricultural reform by adding a special section to the state constitution. Article 13, Section 11 of the 1850 State Constitution declared:

The Legislature shall encourage the promotion of intellectual, scientific, and agricultural improvements; and shall, as soon as practical, provide for the establishment of an Agricultural School. The Legislature...may make the same a branch of the University, for instruction in agriculture and the natural sciences, connected therewith, and place the same under the supervision of the Regents of the University.¹³

¹¹ Dr. H. P. Tappan, *Address to Michigan Agricultural Society, September 1853*: 6-8, 12. UA 17.107 Kuhn Collection, Box 1143R, Folder 67. Michigan State University Archives and Historical Collections.

¹² Dr. H. P. Tappan, *Address to Michigan Agricultural Society, September 1853*: 22-23. UA 17.107 Kuhn Collection, Box 1143R, Folder 67. Michigan State University Archives and Historical Collections.

¹³ Quoted in Keith R. Widder. *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925*. (East Lansing: Michigan State University Press, 2005), 23, ff 28. See also, "Constitutional Provision." *The Agricultural College of the State of Michigan* (Lansing: Hosmer and Fitch, 1857), 9.

Despite this early attempt by state politicians to innovate and modernize the state educational system, it would take another five years of squabbling, debate, and compromise to realize Michigan's agricultural school.¹⁴

On February 12, 1855, the Michigan legislature passed the act which created a new institution, the Michigan Agricultural College. The Agricultural College was the first of its kind in the Midwest and the language of the charter borrowed only sparingly from the agricultural societies and industrial colleges in other states like Illinois and New York. The legislative action also ended the debate over whether to include an agricultural school in Ann Arbor at the University, or to create a completely new institution with a practical emphasis. The State Board of Education assumed authority over the new school's curriculum, which was to include "an English and Scientific Course." The Board hired Joseph Williams, a merchant and miller from Constantine, Michigan, as the first President and charged him with organizing and defending the curriculum and system of education at the new institution. The first building was erected in 1857 just east of Lansing, where land had been acquired for the model farm. In May, faculty began instruction for eighty-one students.¹⁵

¹⁴ For a more detailed examination of the organizational debate for the Agricultural College see Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 1-21; and in Keith R. Widder, *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 15-29.

¹⁵ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 8-16; and in Keith R. Widder, *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 15-29. See also "Act of Organization," *The Agricultural College of the State of Michigan* (Lansing: Hosmer and Fitch, 1857): 12-13. W.J. Beal examined many of the arguments that arose during the debates over creating and organizing the Agricultural College in *History of the Michigan Agricultural College and biographical Sketches of Trustees and Professors* (East Lansing: The Agricultural College, 1915), 6-15. Each college history leans heavily on its own states agricultural background and pertinent society as the "originator" of that state's charter legislation. For example see, Richard G. Moores, *Fields of Rich Toil, The Development of the University of Illinois College of Agriculture* (Urbana: University of Illinois Press, 1970), 3-30; and Gould P. Colman, *Education and Agriculture, A History of the New York State College of Agriculture at Cornell University* (Ithaca: Cornell University Press, 1963), 1-43.

As the first president of the Michigan Agricultural College, Joseph Williams had the daunting task of justifying the existence of the college and laying the foundation of the educational system the college would employ. In an 1858 letter, he noted that “the institution should be good enough for the proudest and cheap enough for the poorest.” Williams envisioned the agricultural college as far more than just a model farm. He wanted coursework that benefited the farming community in every facet; better plants, improved tools, modern business and accounting methods, and innovative manual skill training. Williams not only noted the immediate and practical nature of the college to the state of Michigan. He also recognized that the experiment of providing public education for the working classes lay at the core of improving the business, industry, and agricultural prospects for the entire nation.¹⁶

During the opening ceremonies of the college, Williams played on the idea that Michigan’s pioneer citizens led the way in pioneering educational practices. He noted how agricultural and technical improvements in the past, such as the cradle scythe, the mechanical reaper, clover planting, and saw-mills, had been ridiculed and denounced by detractors before they had even been given a chance. Williams viewed such improvements and labor saving ingenuity as paramount to the success of his state and the country as a whole. Farmers and workers criticized the idea that a school could teach work methods better than they could. Williams countered them by citing examples of wasteful planting methods that put Americans behind Europeans in bushel-per-acre yields, poor animal husbandry practices that reduced the quality of the meat and the continuous spread of contagions and pests that destroyed crops and decimated herds. He agreed that “natural law” provided the foundation for agricultural and

¹⁶ “Correspondence, 1858.” Joseph R. Williams Papers, UA 2.1.1, Box 871, Folder 41. Michigan State University Archives and Historical Collections.

industry, but emphasized that knowledge and intelligence always moved forward and that individuals needed a vehicle for improvement.¹⁷

The system Williams proposed to improve the lives and prosperity of farmers and working class people in Michigan did not exist in any complete form in the United States. However, the concept and practices of an agricultural or industrial school were not new. Europeans had run such institutions for some time. But Williams did not want to model American agricultural schools on the European system which he saw as only training the “stewards, agents, and hirers who use laborers as serfs and instruments.” In the United States, by contrast, one man constituted the landlord, tenant, and laborer, necessitating an education suited to the experiences and prospects of the American farmer.¹⁸

While Williams focused on the agricultural aspects of the college during his tenure as president, he did not ignore other areas that supported or branched out from the agricultural fields. In his funding petition to the Michigan State Legislature in the spring of 1858, Williams argued that the basis of business prosperity and stability rested on the development of sound education in agriculture, manufacturing, and mechanic arts. He pleaded with the

¹⁷ Joseph Williams, “Address and Dedication.” *Catalogue of The Agricultural College of the State of Michigan, 1857* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 24-31. Williams provided a laundry list of financial and practical complaints that had arisen with regard to the opening of the college. He pointed out that the federal government’s annual budget was \$70,000,000 and only \$250,000 of that went towards agricultural endeavors. While agricultural societies urged the federal government to allocate 500,000 acres of land for agricultural education in 1858, Michigan had already asked for 350,000 acres in 1850. When farmers criticized the idea that a college could improve the teaching of practical skills, Williams noted that European and Canadian farmers routinely out-produced American farmers in bushels-per-acre.

¹⁸ Joseph Williams, “Address and Dedication.” *Catalogue of The Agricultural College of the State of Michigan, 1857* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 33. Williams was widely versed on the efforts of agricultural education both in the United States and overseas. In an 1858 address in Syracuse, N.Y, he detailed the efforts of colleges in Germany, France, Russian, and Great Britain. In the United States he noted the chartering and early efforts of supporters in New York, Pennsylvania, Maryland, Iowa, Minnesota, Ohio, and Massachusetts. See J. R. Williams, *Agricultural Education, an address delivered at the State Fair, Syracuse, N.Y., October 8, 1858*: 15-20. Joseph R. Williams Papers, UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections. For more on European technical education and engineering efforts see Frederick B. Artz, *The Development of Technical Education in France, 1500-1850* (Cambridge: The M.I.T. Press, 1966); and Robert R. Locke, *The End of the Practical Man: Entrepreneurship and Higher Education in Germany, France, and Great Britain, 1880-1940* (London: JAI Press Inc., 1984).

politicians to fully fund an agricultural college which “encouraged and promoted” human industry by using a “uniform and general system of education.” Williams based his idea of systematic instruction in agricultural parlance, but he always made clear that there was a direct connection between farming and manufacturing. In this way, he kept the possibility open for instruction in mechanic arts and engineering disciplines without dividing the support of the working class citizens of the state of Michigan.¹⁹

Administrators, professors, and students at the Michigan Agricultural College remained focused on farming related studies during the early years of the school. Supporters of the school consistently put forth the notions that scientific study and guided labor provided the greatest benefits for the state’s agricultural improvement. Early students noted that their sole object of attending the college “was to obtain knowledge in the natural laws.” President Williams used this nugget of propaganda to support the centrality of science courses at the college. He laid out the financial differences between farming with scientific principles and farming with guess-work or established customs. Williams calculated that scientific farming would increase production by millions of dollars. Though he never published his calculations, Williams boasted that scientific agriculture easily doubled the annual production of land without increasing cultivated acres.²⁰

In an effort to placate many in the farming communities who feared that they would send their children to college only to see them return unfit for hard labor on the farm, Williams emphasized a mandatory labor requirement for the college in many of his addresses and reports to the state. European schools and many eastern technical schools used some

¹⁹ Joseph Williams, *Petition for Agricultural College, 1858*. Joseph R. Williams Papers, UA 2.1.1, Box 871, Folder 41. Michigan State University Archives and Historical Collections.

²⁰ Joseph Williams, *The Agricultural College, an address by President Williams, 1858*. Joseph R. Williams Papers UA 2.1.1 Box 871, Folder 46. Michigan State University Archives and Historical Collections.

form of manual labor to supplement their staff labor. At Michigan's Agricultural College, students would work on the farm for specified number of hours each day, enhancing their classroom studies with practical training and "healthy exercise." In 1858, Williams stressed that 85% of his school's student body came from lower class or farming backgrounds which met his goal of opening education to all. Williams also noted that most of his students had not received adequate reading or English instruction at their common schools. However, in the first nine months they had attended the agricultural college, Williams reckoned they had increased their knowledge more than at any other time. More than that, Williams declared the labor students performed not only provided valuable training, but virtually eliminated sickness at the institution.²¹

Clearly, Williams had to defend the institution on two fronts. For the politicians and agricultural societies who funneled the necessary funding to the college, he had to demonstrate the importance of science instruction and assert the unique value of the college for training the state's farmers and workers in methods that would improve economic productivity. To the farmers and laborers, Williams had to alleviate concerns that students would leave the farms and shops they came from. His emphasis on superior methods of production and the value of labor highlighted the importance of improving the condition and status of the working classes.

²¹ Joseph Williams, *The Agricultural College, an address by President Williams, 1858*. Joseph R. Williams Papers UA 2.1.1 Box 871, Folder 46. Michigan State University Archives and Historical Collections. Williams consistently combined the study of agriculture with the practices of farming. He repeatedly used the phrase "This was to be a place of careful study of sciences that lean upon the art of farming, study backed by experiment and lab, observation and field labor." For example, see *Biographical and Autobiographical material, 1859*. Joseph R. Williams Papers UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections; Joseph Williams, "Addresses Delivered at the Opening Ceremonies of The Agricultural College." *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 25-45.; and J. R. Williams, *Agricultural Education, An address delivered at the State Fair, Syracuse, N.Y., October 8, 1858*. Joseph R. Williams Papers, UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections.

In his address at the opening ceremonies of the college in 1857, Williams laid out his rationale and the system of education he envisioned. The new agricultural college filled the void in modern science and practical business that the University of Michigan still neglected. In particular, Williams highlighted the fact that higher institutions in the east did not provide any meaningful knowledge or new systems of study that benefited agricultural interests or those involved in farming related activities. In fact, Williams specifically stated that existing universities made men “accomplished for professional life, while tastes and habits were acquired, which created indifference and inaptitude to the most healthy and rational of the occupations of man.” Clearly, Williams played to the rural crowds with this sentiment, but his message hit the mark. He wanted the new agricultural institution to make better farmers and laborers, improve production methods, and keep the students on the land and out of the eastern cities.²²

Williams focused on agricultural endeavors in his speech. He had to explain the importance of technical innovation and improved production methods, and also to justify the cost and acquisition of land-grants, especially when compared to federal spending in general. Williams also strove to emphasize the uniqueness of the new system of instruction at Michigan’s agricultural school, as opposed to what Europeans had done or what other states like New York, Pennsylvania, or Iowa were attempting.²³

William’s new system of education for the college combined scientific instruction with practical and applied labor. “A sound mind in a sound body” became Williams’ mantra for the school. European Polytechnic Schools and the U.S. Military Academy engaged

²² Joseph Williams, “Addresses Delivered at the Opening Ceremonies of The Agricultural College.” *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 24-25.

²³ Joseph Williams, “Addresses Delivered at the Opening Ceremonies of The Agricultural College.” *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 26-34.

students in hours of intense physical exercise. Classical schools instituted gymnastic exercises as a nod to physical health. But Williams called for labor that directly applied to the students' learning. He wanted his boys in the fields planting, cultivating, and harvesting. He wanted them employed in developing the college grounds, clearing trees, building fences, and constructing barns. Williams called his plan for practical labor a "vital, cementing, invigorating influence that will give the school dignity and hopefully complete success."²⁴

Williams saw labor as the connecting fiber of the institution, combining the acquisition of scientific knowledge with the productive application of skills and methods. But the mind needed cultivating just as much as the land. Williams called for an Agricultural Library, Museum of Models of Agricultural Implements, a chemical and philosophical laboratory, a cabinet of natural science, a collection of animal and insect specimens, a horticultural garden, and a completely operational farm. While farming activities and applications necessarily dominated the organizational plan, Williams' proposed components of the college included a healthy system of technical knowledge, applied science, and engineering.²⁵

While engineering studies did not specifically exist in Williams' original plan, practices of engineering did. He recognized that general and applied work of farming involved a wide variety of technical and mechanical skills. Farmers needed to design and construct their own implements, survey their farm lands, and level lands for drainage, roads, and cultivation. These activities defined the basic duties of mechanical and civil engineers; mechanical design and manufacture, land surveying, and infrastructure construction.

²⁴ Joseph Williams, "Addresses Delivered at the Opening Ceremonies of The Agricultural College." *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 35-36.

²⁵ Joseph Williams, "Addresses Delivered at the Opening Ceremonies of The Agricultural College." *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 37-39.

Williams outlined an extensive curriculum for science instruction. His ideas basically fell into two categories; natural sciences and physical sciences. He included applied chemistry for the house and field, plant and animal physiology, veterinary arts, entomology, and natural philosophy, which included special topics in mechanics, materials science, construction, laws of motion, electricity and magnetism, and laws and uses of motive agencies. Again, no mention of engineering coursework entered the college curricula at this point, but Williams laid the foundation for such study and emphasized the importance of technical skills in farm work and the improvement of agriculture.²⁶

Within a year, and while addressing a crowd at New York's State Fair, Williams did include civil engineering and the "application of science to the mechanic arts" in his explanation of the chief features of an agricultural institution. He had crafted his message around the idea of the demand for an "education of the new man." And while still focusing on agricultural education, Williams now incorporated the adaptation and use of new modern physical sciences, mathematics, mechanic arts, and engineering.²⁷

Despite Williams high-minded conceptual plans for the college, the politicians and public were well aware of the meager beginnings of the institution. In a speech before the state legislature in January, 1859, Governor Moses Wisner praised the early efforts of college organization and college's model farm development, while simultaneously chiding the administrators and previous administrations for their poor choice of location. Proponents had

²⁶ Joseph Williams, "Addresses Delivered at the Opening Ceremonies of The Agricultural College." *The First Annual Catalogue of The Agricultural College of the State of Michigan* (Lansing: Hosmer & Fitch, Book and Job Printers, 1857), 40-42. Williams outlined his curricula plans in similar detail in an 1858 address at Syracuse, New York during their State Fair. He included mathematical studies as a catch-all for the physical sciences and engineering, but still applied them to agricultural work. J. R. Williams, *Agricultural Education, An address delivered at the State Fair, Syracuse, N.Y., October 8, 1858*. Joseph R. Williams Papers, UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections.

²⁷ J. R. Williams, *Agricultural Education, an address delivered at the State Fair, Syracuse, N.Y., October 8, 1858*: 25-26. Joseph R. Williams Papers, UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections.

created legislation that required the college and farm site be within ten miles of Lansing and not exceed fifteen dollars an acre. The only lands available for this price that close to the capital city were salt-flats and tree-covered lands to the east and south. However, this seemingly ill-conceived plan for the college offered an early entry for civil and mechanical engineering efforts by college students.²⁸

As noted by Governor Wisner in his address and by college administrators and faculty in their early reports to the State Board of Agriculture, students had a great deal of non-farm labor to complete before the agricultural studies and farm labor could start. Students and the handful of professors had to clear the dense growth of trees and scrub from the land surrounding the Red Cedar River. To do this, they often employed a new stump-pulling device that Michigan mechanics had improved upon in the late 1850s. The students also helped rebuild the bridge over the river so that the school and farm lands could be easily accessed. And students also helped in the construction of barns, equipment sheds, and workshops for the farm and college. Though politicians and students might have recognized this work as simply necessary to getting the college and farm started, it actually provided a great deal of applied study in civil and mechanical engineering.²⁹

Despite an apparent good start by administrators and professors after 1857, the college instructors and students encountered controversy that persisted between 1859 and 1861. President Williams resigned in March 1859 as a result of accusations of over-spending and his

²⁸ Moses Wisner, "Extracts from the Message of Various Michigan Governors Relating to the State Agricultural College, January 5th, 1859." Kuhn Collection, UA 17.107, Box 1140, Folder 52. Michigan State University Archives and Historical Collections.

²⁹ Moses Wisner, *Extracts from the Message of Various Michigan Governors Relating to the State Agricultural College, January 1st, 1861*. Kuhn Collection, UA 17.107, Box 1140, Folder 52. Michigan State University Archives and Historical Collections. The use of a new stump pulling machine offered presidents and faculty numerous opportunities to tout the modern practices and technology of the college. For example, see the *Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, For the Year 1866* (Lansing: John A. Kerr & Co., Printers to the State, 1866), 11. Michigan State University Archives and Historical Collections.

personal political ambitions. He would go on to a successful career as a Michigan state senator and have a direct influence on the passage of the 1862 Morrill Act. But his departure from the college meant that his influence on a broad and applied four-year curriculum also disappeared.³⁰

Guided by John Gregory, the State Board of Education instituted a two-year program of instruction designed to specifically focus on farm management. The Board hoped the shorter program would interest more farmers with quick, specialized instruction and lower cost of attendance. Faculty and students demanded that a four-year curriculum be reinstituted, but the Board's two-year program remained in effect between 1859 and 1861. The restructuring of the curriculum decimated the elementary science and non-science courses, including the loss of literature, history, mathematics, and philosophy. Students had to make up deficiencies in algebra, geometry, trigonometry, and general chemistry in a one-year preparatory course before they could enter the regular two-year program. The ineptitude of the restructuring was exemplified by the reassignment of Theophilus Abbot, the professor of English literature, as the new professor of civil and rural engineering for one year. However, this restructuring by Gregory and the State Board of Education did allow for the specific inclusion of engineering coursework for the first time.³¹

Gregory's plan had numerous flaws and an intentional structuring so as to keep the lower classes from gaining admission or attending the college. He required mathematics and science coursework that could only be obtained in the cities and crammed so many studies into two years that it was nearly impossible for anyone to finish the program in the two-year

³⁰ Keith R. Widder. *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 39-43.

³¹ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 52-56.

time frame. But Gregory did push to add qualified professors, especially in engineering related studies, and implemented an engineering program that offered a year of systematic science and a year of applied science. Students took preparatory courses in chemistry, algebra, geometry, and trigonometry, followed by drawing and surveying, and concluding with specialized mechanical and civil engineering courses. Interestingly, students completed both areas of engineering in the second year, mechanical engineering in the fall and civil engineering in the spring. College and public records do not account for the ultimate career directions of students from this era, undoubtedly because none of them made good engineers of any kind after such a rushed educational experience. Most either returned to the farm or were drafted into the Union army and never returned to advanced studies.³²

Joseph Williams' election to the Michigan Senate in 1860 allowed for a better supported attack on Gregory's changes to the college and eventually led to a new organizational structure for the institution. Faculty and students had remained vocal about the curriculum deficiencies. Williams pushed through "An Act to Reorganize the Agricultural College, and to Establish a State Board of Agriculture." Designed by Williams, the new legislation enforced courses in English, agricultural studies, and the sciences, and defined the role of the farm as a contributor to the research activities of the school. Williams also included sections for publication of activities and research in an annual report to the State Board of Agriculture. He added provisions ensuring the independence of the college from political influence but closely binding the governance of the institution to Michigan's agricultural community. The new State Board of Agriculture governed the institution, while the county agricultural society provided lists of nominees for future members. Further, the

³² Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 55-57.

board secretary had the responsibility of publishing reports, circulars, and articles about the research and activities of the college in local and state papers so that state organizations and the public had access to the work and findings of the agricultural college. Moreover, Williams inserted a detailed list of courses in section 15 of the Act, which included civil engineering and “especially the application of sciences and the mechanic arts to the practical agriculture in the field.”³³

Williams moved his efforts for agricultural education to the national level even before he worked out the Michigan details between 1859 and 1861. He played an instrumental role in helping Justin Morrill of Vermont formulate the 1862 Land-Grant College Act, also known as the Morrill Act. In his address to New York State Fair goers in 1858, Williams identified the national scale of the “new order of Agricultural and Industrial Colleges,” and identified numerous states in North, South, and Midwest that had already established or would soon charter agricultural schools.³⁴ As legislators worked the bill through Congress and past sectional divisions, the concepts of agricultural and mechanic arts education became permanently intertwined. When President Lincoln signed the Morrill Act in 1862, he based his support on the Republican ideal of “free labor” which he insisted required universal education for farmers, laborers, and all so-called “industrial classes.” Congress’s passage of

³³ “An Act to Reorganize the Agricultural College of the State of Michigan, and to Establish a State Board of Agriculture, 15 March 1861.” *The Compiled Laws of the State of Michigan*, comp. James S. Dewey (Lansing: W.S. George and Co., 1872), 1183. The measures included in the Act are discussed in W.J. Beal, *History of the Michigan Agricultural College and Biographical Sketches of Trustees and Professors* (East Lansing: The Agricultural College, 1915), 37. Details regarding Section 15 can be found in “Miscellaneous University-Act of Reorganization of the Agricultural College of the State of Michigan, Feb 18, 1861,” Kuhn Collection, UA 17.107, Box 1141, Folder 72. Michigan State University Archives and Historical Collections.

³⁴ J.R. Williams, “Agricultural Education, an address delivered at the State Fair, Syracuse, N.Y., October 8, 1858,” Williams Papers, UA 2.1.1 Box 871, Folder 47. Michigan State University Archives and Historical Collections. Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: Iowa State College Press, 1942), 21. Keith Widder examines the connections between the passage of the land-grant act and the expansion of American democracy to the working classes, especially with the close ties between Michigan’s Agricultural College and the framing of the 1862 Morrill Act. See Keith R. Widder. *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 44-48.

the 1862 Morrill Act gave agricultural colleges, and especially Michigan's first-in-the-nation effort, a promise of permanence and sense of legitimacy. What had largely begun as an agricultural effort for better, more scientific education in the early 1850s had grown to a national effort to improve the educational opportunities of all working class Americans in less than a decade.³⁵

Michigan lawmakers actually made little fanfare out of accepting the 1862 Morrill Act, though the funding rejuvenated and enhanced the educational efforts of the Agricultural College. Michigan's legislature had asked for an educational land-grant in 1850, but the request had fallen on deaf ears. In 1858, Senator Justin Morrill pushed for national education funding, using Michigan's early efforts as an example of what he intended. While the law was still pending in Congress, legislators in Michigan accepted "any such grant or donation of lands now made or which may hereafter be made by Congress to this State." The Legislature reaccepted the Morrill Act funding in 1863, obviously forgetting about their earlier statement. State boards and agents bickered and stumbled through the process of selecting lands, but eventually the college accumulated a fund of three hundred thousand dollars by 1885 by selling just half their allotted land grant.³⁶

³⁵ Lincoln expounded on the benefits of agricultural education and improved learning in an address to the Wisconsin State Agricultural Society in 1859. See Abraham Lincoln, "Address before the Wisconsin State Agricultural Society, Milwaukee, Wisconsin," 30 September 1859, in *The Collected Works of Abraham Lincoln*, ed. Roy P. Basler, Marion Dolores Pratt, and Lloyd A. Dunlap (New Brunswick: Rutgers University Press, 1953), 480. On the importance of "free labor" to the Republican movement, see Eric Foner, "Free Labor and Nineteenth-Century Ideology," in *The Market Revolution in America*, ed. Melvyn Stokes and Stephan Conway (Charlottesville: University Press of Virginia, 1996), 99-127; and Eric Foner, *Free Soil, Free Labor, Free Men: The Ideology of the Republican Party Before the Civil War* (New York: Oxford University Press, 1995), ix-39.

³⁶ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 71-75. Kuhn provides a detailed account of how the federal lands were selected and for what reasons. Michigan board members focused on land quality rather than resources, neglecting timber lands in the north. Michigan benefited from a wide variety and placement of lands, something eastern states could not rely on since most of the older state's land was held by private citizens. High interest rates also helped the College. At 7% rates, the College turned \$58.96 in land holdings in 1869 into \$29,770 in 1885. No other state managed its 1862 Morrill Act grant as successfully.

The early staff of the Agricultural College made their lasting imprint with a bold step forward in educational practice. Joseph Williams, Lewis Fisk, the University of Michigan educated professor of chemistry, and Calvin Tracy, a Dartmouth graduate and professor of mathematics, all came from colleges that used the classical method of instruction based in Greek, Latin, rhetoric, philosophy, mathematics, and a little physical science. Fisk had gained a little laboratory experience at Harvard's Lawrence Scientific School. But these men foresaw the need for a different curricular program, based in applied sciences rather than classical studies.³⁷

Williams, Fiske, and Tracy placed the foundation of their change in the substitution of sciences for Greek, Latin, and other foreign languages. Initially, they omitted "agriculture" from the lists of studies, since the subject didn't exist at classically oriented universities. Williams and his cadre of professors held to the wording of the law, that the College had been founded to teach "scientific agriculture," and they argued that the college laboratories and experimental farm plots would be the center for this area of study to be created and developed.³⁸

Michigan farmers and industrialists made huge advancements in the 1860s. Farmers enjoyed uninterrupted access to both their traditional markets and the Eastern states due to expanding networks of roads and railroads. They also took advantage of rising prices for commodities, and many moved from subsistence farming into commercial agriculture. Northern peninsula farmers took advantage of the food market for successful mining operations that needed to feed their labor forces by increasing their production of surplus

³⁷ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 25-26.

³⁸ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 27.

crops and livestock. With the Civil War drain of men towards the battle front, farmers looked to mechanical devices to help increase production and improve efficiency. Opportunities for mechanics and businessmen engaged in producing machinery and supplies increased as well, so that the scale of enterprise grew state-wide from 108 businesses in 1860 to 164 in 1870, mostly in and around the city of Detroit. Farmers and businessmen alike felt the dire need for more scientific and efficient agricultural and mechanical production. They looked first towards the institution in Lansing which promised exactly these kinds of returns.³⁹

While agricultural instruction and the acquisition of funding dominated the attention of college administrators and professors in the 1860s, science and engineering professors quietly built up the necessary curriculum and equipment for technical instruction. Lewis Fisk oversaw the construction and equipping of the science laboratories from 1857 to 1863. He had been the professor of natural science at the Ypsilanti Normal School for three years when organizers approached him in 1857 about organizing the science laboratories and science curriculum at the new agricultural college. Beginning in 1857, Fisk used the newly appropriated funding for a complete set of chemical apparatus, mechanical apparatus, and mathematical instruments, including numerous pieces of surveying equipment.⁴⁰

Fisk also made a point of laying out his program of study to the state board. He first acquainted students with the general laws and principles of chemistry and natural philosophy using a full year course of “experimental lectures” to demonstrate the fundamental ideas. Second, he had students work in the chemistry laboratory, widely considered the best outside of eastern medical schools. Once the students had demonstrated adequate performance in the

³⁹ Martin J. . Hershock, *The Padox of Progress: Economic Change, Individual Enterprise, and Political Culture in Michigan, 1837-1878* (Athens: Ohio University Press, 2003), 194-196.

⁴⁰ Lewis Fisk, “Facilities for Instruction.” *Report to State Board April 1861*, 8-11. Lewis R. Fiske Papers, UA 2.1.2, Box 862, Folder 9. Michigan State University Archives and Historical Collections. Fisk went to the older spelling Fiske after he left the Agricultural College in 1863. Quoted in Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 16.

classroom and laboratory, Fisk taught applications of chemistry to agriculture. Fisk made similar curricula plans for mechanics and mathematics as they applied to machines and surveying.⁴¹

Professors never lost sight of the importance placed on agriculture by supporters, but they found ways to highlight mechanical knowledge in their promotion of the Agricultural College. In October of 1861, Lewis Fisk addressed the Macomb County Agricultural Society in Romeo, Michigan. Aware of his audience, he detailed the benefits of learning the sciences, systematically applying laboratory knowledge to the improvement of fertilizers, seeds, and animal husbandry. He touted the benefits of manual labor performed by students at the school. But he also stressed the fundamental importance of mechanical knowledge. Fisk placed the act of “doing” farming on an equal footing with “knowing” farming. Students gained knowledge in the theories of biology, chemistry, and botany. But they put that knowledge into practice by learning how to manipulate the machinery and skillfully employ the implements of farming. Fisk also noted that electricity and steam power pushed the boundaries of science outward and so promised to expand the capabilities of farming. But farmers had to have knowledge of these improvements so they could properly integrate and apply the technical benefits to their agricultural efforts.⁴²

The inclusion of specific engineering coursework into the College’s four year program of study and course catalogue coincided with the acceptance of the 1862 Morrill land-grant funds. In 1862, first year students had a semester of algebra, and a semester of trigonometry

⁴¹ Lewis Fisk, “Facilities for Instruction.” *Report to State Board April 1861*, 8-11. Lewis R. Fiske Papers UA 2.1.2, Box 862, Folder 9. Michigan State University Archives and Historical Collections. See Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 16, 25-26.

⁴² L. R. Fisk, *Address delivered before the Macomb County Agricultural Society, at Romeo, October 4th, 1861* (Romeo, Michigan: Printed at the Argus Office, 1861), 3-5. L. R. Fiske Papers, UA 2.1.2, Box 862, Folder 8. Michigan State University Archives and Historical Collections.

and surveying. They took one semester of physics in their second year and a semester of “connection of physical sciences” during the last semester of their fourth year. But all students at the Agricultural College took courses in civil engineering, drawing, and rural engineering as part of the third year program of study, presumably to assist with farm surveying and field leveling.⁴³

Administrators began focusing on a more holistic and systematic approach to education at the Agricultural College at this time. In the school catalogue’s “Objects of the Institution” section, they stated, “The benefits arising from the increase and diffusion of scientific knowledge, and its implications to the industrial pursuits can hardly be estimated.” By using “industrial pursuits” as an inclusive term for farming and mechanic arts, the college’s administrators opened the door to all working classes, rather than just farmers.⁴⁴

While students might have gained only a vague sense of “industrial pursuits” outside of farming from the program of study section, the course section provided a much more explicit description of the topics and applications they could expect. The preparatory class spent time with a review of general arithmetic and basic algebra. But once fully admitted, students studied algebra, geometry, trigonometry, and conic sections. As part of their civil engineering studies, students studied the processes of topographical surveying, leveling, and plotting. As part of the physical sciences, students then studied mechanics, material strengths, arches and framing, bridge and road building, and industrial drawing. The catalogue mentioned chain, compass, and level instruments as part of the practical study. Students also

⁴³ *Catalogue of the Officers and Students of the State Agricultural College, 1862* (Lansing: John A. Kerr & Co., Book and Job Printers, 1862), 16-17. Michigan State University Archives and Historical Collections.

⁴⁴ *Catalogue of the Officers and Students of the State Agricultural College, 1862* (Lansing: John A. Kerr & Co., Book and Job Printers, 1862), 12-13. Michigan State University Archives and Historical Collections.

gained practical experience with road construction and barn framing by working on the college grounds and farm as part of their manual labor requirement.⁴⁵

Administrators made greater changes in the school purpose and program of study in 1863, following the official acceptance of the Morrill land-grant funds. The first mission of the college, according to the 1862 catalogue, was to “impart a knowledge of science and its applications to agriculture.” In 1863, college officials changed the point to “impart a knowledge of science, and its applications to the arts of life.” Williams and his staff clearly meant to maintain the predominance of agriculture, but they also understood the broader nature of education mandated by the language of the 1862 Morrill Act. While they promoted agricultural studies, experiments, and associated manual labor as the primary focus and reason for the College’s existence, they also wanted to encourage the development of other technical studies that supported the agricultural fields. In the early years, Agricultural College personnel typically advanced the concepts of civil and mechanical engineering couched in terms of mechanics as applied to implements, surveying and leveling, and building and construction techniques.⁴⁶

Professors also changed the program of study in 1863. Freshmen took algebra and geometry in their first semester, and trigonometry and surveying in the second semester. Sophomores took a full year of physics and chemistry. Juniors had a semester of industrial drawing. And in a change from the previous year, seniors, instead of juniors, received a semester of civil engineering coursework. The semester of “rural engineering” was replaced

⁴⁵ *Catalogue of the Officers and Students of the State Agricultural College, 1862* (Lansing: John A. Kerr & Co., Book and Job Printers, 1862), 22, 26. Michigan State University Archives and Historical Collections. Fisk had acquired mechanical as well as chemical apparatus for the science laboratories. Under philosophical apparatus, the catalogue mentioned “apparatus for illustrating the principles of mechanics, heat, electricity, galvanism, etc.” This equipment was probably used more for demonstration purposes in the classroom rather than as laboratory equipment the students could work with.

⁴⁶ *Catalogue of the Officers and Students of the State Agricultural College, 1863* (Lansing: John A. Kerr & Co., Steam Book and Job Printers, 1863), 12-14. Michigan State University Archives and Historical Collections.

with monthly lectures in “manual operations on the farm,” and weekly or monthly drills in infantry tactics, and military fortifications and field operations.⁴⁷

Professor Tracy did not change the topics and content of his mathematics and civil engineering courses between 1862 and 1863. He did add that students received instruction “in the field as well as in the lecture room.” He also noted the new requirement that each student had to take charge of field surveys and become “well acquainted” with the use of surveying equipment such as the level, compass, and chain. Tracy’s concise approach to describing his class managed to symbolize the educational system created at the Michigan Agricultural College. He laid out a foundation of mathematical and scientific theories for the classroom and then moved on to field applications in which the student had to show mastery. Students gained their field experience through a variety of methods and at various times, including laboratory work and manual labor hours. But the manual labor was not just dreary field work. The professors expected the students to assist in scholarly experimentation while working on the farm, thus learning how to conduct experiments to further the science of agriculture.⁴⁸

College personnel continued to defend the new system of education they employed. In his 1866 report to the State Board of Agriculture, college president Theophilus Abbot praised the monumental efforts of the faculty and students in adopting and improving the methods of scientific and experimental work of the institution. He noted that Michigan was the first state to take practical steps towards the wants of the people regarding useful knowledge. Further, the leaders of the Agricultural College had “labored without guide or example.” Classically oriented colleges had hundred of years of trial, error, experience, and

⁴⁷ *Catalogue of the Officers and Students of the State Agricultural College, 1863* (Lansing: John A. Kerr & Co., Steam Book and Job Printers, 1863), 17-19, 27. Michigan State University Archives and Historical Collections. The report noted that military instruction had been offered for several years, but that the college would promote the mandate of the law by offering more military drill and instruction during the four year program of study.

⁴⁸ *Catalogue of the Officers and Students of the State Agricultural College, 1863* (Lansing: John A. Kerr & Co., Steam Book and Job Printers, 1863), 25, 28. Michigan State University Archives and Historical Collections.

accumulated wealth and investigation to rely on when putting together systems of instruction. Michigan's institutional organizers and faculty had constructed a "system adapted to her needs." Abbot encouraged the idea that the system would continue to develop and expand as long as other schools and future generations, as well as a patient public constituency, continued to experiment and invest in practical education.⁴⁹

Students, faculty, supporters, and the educational system employed at the Michigan Agricultural College benefited from President Abbot's long and relatively stable tenure. He had supported the agricultural foundation of the college during its first years, while simultaneously providing the college with its full complement of English, history, and philosophy courses. He did not have the political strength of Williams, the scientific background of Fisk, or the agricultural experience of the rest of the faculty. But he did possess a tireless enthusiasm for the new educational system and a deep pride in the college's "first-in-the-nation status" among agricultural colleges.⁵⁰

The national depression of the 1870s slowed the agricultural and manufacturing boom that had fueled the state's economy in the 1860s and had thereby boosted the importance of the training provided by the Agricultural College. Manufacturing was still dominated by on small establishments that could more easily maintain the apprenticeship system of instruction, limiting the need for training in mechanical arts at the Agricultural College. Those industries that did grow and prosper in Michigan tended to include those that relied on food-processing and the direct availability of natural resources such as lumber, coal, iron, and copper. Farmers continued to dominate the state's commercial industries, with connections to food processing

⁴⁹ Theophilus Abbot, "State Agricultural College." *Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, for the year 1866* (Lansing: John Kerr & Co., Printers to the State, 1866), 7-9. Michigan State University Archives and Historical Collections.

⁵⁰ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 70.

plants that dried apples and developed canning techniques for corn and tomatoes. Those mechanized industries that did succeed focused on agricultural machinery. The Gale Manufacturing Company, in Albion, focused on plows and cultivators. The Advance Thresher Company, in Battle Creek, produced traction engines and threshers. And the Nichols & Shepard Company produced self-propelled steam powered threshing machines that farmers could cooperatively share between their farms. Administrators at the Agricultural College maintained their focus on farming skills and practices, branching out into mechanical arts only so far as they involved farm machinery.⁵¹

Despite Abbot's promotion of the college, the new educational system, and the agricultural experiments faculty and students conducted, engineering studies struggled to find a strong foothold. Faculty knew that civil and mechanical engineering curricula had a secured place at the institution; the mandate of the 1862 Morrill Act to promote "agriculture and the mechanic arts" ensured that. But through the 1870s, reports and addresses emphasized agricultural efforts and achievements.

In his 1870 report to the State Board Agriculture, Abbot specified the total teaching force of the institution; the President, and Professors of Agriculture, Chemistry, English and Literature, Entomology, botany, and a Superintendent of the Horticultural Department. Abbot's reason for listing the faculty was not to point out deficiencies in instruction, but rather to praise their hard work, note their growing popularity, and ask for larger salaries. He also requested more money for buildings and laboratory equipment. In detailing the progress and success of graduates, Abbot did note that five past graduates had become engineers, surveyors, and machinists. He never mentioned the limitations of mathematics and

⁵¹ Willis F. Dunbar, *Michigan, A History of the Wolverine State*, 3rd ed., ed. by Georgy S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 393-397.

engineering instruction or the requirements for mechanical laboratory space and equipment. He did mention the lack of proper workshops, but only in connection with the college farm. He also mentioned the excavation and leveling work students performed on the college grounds, but not their need for proper guidance and instruction in civil engineering work.⁵²

In 1871, the chemistry department did receive a huge boost. That year, the Michigan Legislature provided an appropriation of \$10,000 towards the construction and outfitting of a modern laboratory. President Abbot and his staff recognized an immediate need to enlarge the laboratory since the freshmen and sophomore classes of that year were larger than predicted. In fact, the graduate who detailed the new laboratory for the *Lansing Republican* stated that the laboratory afforded “all the modern conveniences” and left “almost nothing to be desired,” except to have the rooms a little larger.⁵³

The college population was growing. Administrators successfully procured more financial support for the buildings, equipment, and salaries. The size of entering classes steadily increased from a low of 18 students in 1864-65 following the Civil War, to 84 in 1870, and over 200 by the end of the decade. The college focus on agricultural studies correlated to the high proportion of students majoring in that field.⁵⁴

However, administrators and faculty had built an educational system based in the sciences and fundamentally reliant on practical application. Though agricultural studies and

⁵² T.C. Abbot, “State Agricultural College.” *Ninth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, for the year 1870* (Lansing: W.S. George & Co., Printers to the State, 1870), 8, 10-12, 14. Michigan State University Archives and Historical Collections. Though five graduates seems like a paltry number, in 1870 there were only forty-one living graduates of the college. Abbot also noted that only half the graduates returned to the farm at that time.

⁵³ E.B. Fairfield, “New Chemical Laboratory,” *Lansing Republican*, 9 November 1871. The article was reproduced by the Secretary of Agriculture for the Annual Report. See the *Tenth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, for the year 1871* (Lansing: W.S. George & Co., Printers to the State, 1870), 8-20. Michigan State University Archives and Historical Collections.

⁵⁴ *M.A.C. Enrollment Histogram 1857-1907*. Kuhn Collection UA 17.107, Box 1141, Folder 126. Michigan State University Archives and Historical Collections.

students remained the primary focus in the institution, college faculty maintained a broader outlook for the college curriculum. In an 1872 speech, President Abbot defended the Agricultural College's philosophy of education and system of instruction. He stated that with "a systematic acquaintance with the sciences, and owing to the systematic learning they have in it," men stood "vastly higher in the world than others of much better natural abilities." Abbot's case for the benefits of the educational system based in the sciences was in fact not agriculturally connected. He made his point by noting, "The best civil engineers in the world are those who are most thoroughly grounded in the sciences that underlie it." Though agricultural studies still dominated the students' lives at the college, Abbot seemed to provide foresight into where the college would grow in the coming decades. Abbot viewed the system of education developed at the Michigan Agricultural College as a solid foundation for any area of scientific instruction that included practical application.⁵⁵

Despite Abbot's broad vision for the College's system of instruction, engineering continued to be integrated into the mathematics curriculum during the early 1870s. Seniors received twelve weeks of applied mathematics and civil engineering instruction. Juniors and seniors took mechanics during the second term, combining mathematics, sciences, and shop work during the term of instruction. Albert Cook, instructor in mathematics and by default instructor in civil engineering, noted that students received instruction in two categories; building materials and strength of materials. This meant that students worked with mortars, cements, masonry, woods, and metals for construction projects that included arches, framing,

⁵⁵ Theophilus Abbot, *Education is Seeing*. Theophilus C. Abbot Papers, UA 2.1.2, Box 861, Folder 66. Michigan State University Archives and Historical Collections.

bridge, and road building. Students performed all of their surveying work as part of their practical mathematics work.⁵⁶

By the mid-1870s, engineering began to garner more attention from the faculty and administration. Rolla C. Carpenter, an 1873 graduate of the University of Michigan, began teaching surveying in 1874 and took over all the mathematics and engineering courses in 1876. At this time, he began the restructuring process of the necessary classes to give engineering more autonomy within the curriculum.⁵⁷

Carpenter organized his engineering coursework over a twelve week period of the senior year. In his first year of teaching in 1876, he retained the previous textbook and manual labor plan, admittedly because his own lectures were incomplete and in his opinion, no textbooks addressed the needs of the college students and engineering curriculum. Carpenter gave lectures on framing principles, material strengths, roof and bridge truss analysis, criticisms of current roof framing and bridge building techniques, principles of road building, and use and construction of farm machinery. Clearly, Carpenter focused his practical engineering studies on rural needs and activities. Though the textbook did not meet his overall needs, Carpenter focused on limes, mortars, cements, masonry and carpentry principles, and bridge building theory. Since he admitted that his own lectures were not complete, these construction techniques were obviously his own weak areas. In his second year of teaching engineering, Carpenter was able to adopt a more practically oriented

⁵⁶ “Departments of Instruction.” *Catalogue of the Officers and Students of the State Agricultural College of Michigan, 1872* (Lansing: W.S. George & Co., Printers and Binders, 1872), 17-19, 26. Michigan State University Archives and Historical Collections.

⁵⁷ R.C. Carpenter earned the degree of Civil Engineer at the University of Michigan, though that schools program only marginally better than the coursework the Agricultural College offered. Carpenter taught classes in surveying, algebra, geometry, trigonometry, astronomy, mechanics, and civil engineering. After his brother Louis Carpenter arrived in 1881 to take over algebra, geometry, and free-hand drawing, Rolla began teaching mechanical drawing and agricultural engineering. See Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 104.

textbook and rearrange the topics accordingly. Carpenter also took his senior class into Lansing to observe the construction of the capital building to “thoroughly examine the whole operation of practical building.”⁵⁸

Practical applications dominated Carpenter’s engineering courses. The types of problems he gave to students focused on original bridge and roof truss design, based on strength and condition requirements he set for them. He also attempted to cover the principles, construction, and use of farm machinery, again asking students for original designs. The equipment of the mathematics and engineering department in the mid-1870s also reflected the practical nature of the curriculum. Carpenter listed available equipment, including one transit, level, railroad compass, vernier compass, several steel and iron chains, and surveying pins and pickets. For the classroom, students had the use of a friction apparatus, falling body apparatus, and over 2000 models of agricultural and industrial machinery valued at over \$5000.00. The rest of the department’s equipment, tools, and storage cases were valued at \$514.00. Carpenter considered the models and classroom apparatus as valuable demonstration pieces, but the surveying equipment had the greatest value to the student’s practical application and Carpenter’s campus activities.⁵⁹

R.C. Carpenter’s workload extended beyond the classroom. He had his first surveying class help him locate a route from Union to Lansing in 1874. He surveyed and mapped the college grounds during his first few years on campus, including detailed surveys and maps of

⁵⁸ R.C. Carpenter, “Report of the Department of Engineering and Mathematics.” *Fifteenth and Sixteenth Annual Reports of the Secretary to the State Board of Agriculture of the State of Michigan, September 30, 1876 and 1877* (Lansing: W.S. George & Co., State Printers and Binders, 1876), 125, 68. Michigan State University Archives and Historical Collections.

⁵⁹ “Inventory of Department of Mathematics and Engineering, September 30, 1877.” Kuhn Collection. UA 17.107, Miscellaneous University Folder. Michigan State University Archives and Historical Collections. A complete list of the college models was provided in the 1876 annual report. See *Fifteenth Annual Report of the Secretary to the State Board of Agriculture of the State of Michigan, September 30, 1876* (Lansing: W.S. George & Co., State Printers and Binders, 1876), 59-65. Michigan State University Archives and Historical Collections.

the topography and water system of the college and farm grounds. He designed the second Farm Lane Bridge in 1875, to allow access to the campus grounds from the road into Lansing. He also designed an ice house in 1880, the mechanical shops in 1885, and the agricultural laboratory in 1889. He supervised the completion of the campus steam plant in 1884 and installed fire-hydrants and upgraded the campus water system in 1883 and 1884. After six years of using the dormitory roof as an astronomy platform, he oversaw the construction of a campus observatory in 1880. Carpenter lived the educational philosophy of the college, science theory applied to practical applications.⁶⁰

Carpenter was acutely aware of the Agricultural College's main focus, despite his attention to large-scale building techniques and activities. In 1878, he provided a list of lectures he gave connecting civil engineering to agriculture. He gave instruction on farm architecture, principles, use and care of farm machinery, and construction and care of common roads. He did note that the coursework remained rudimentary and general in character because so much had to be covered during the senior year.⁶¹

Carpenter's focus on practical engineering was also highlighted by the placement of mechanics and civil engineering in the summer term. Where professors before 1875 had maintained engineering and mechanics instruction during the fall terms, Carpenter taught them in the summer months so he could use the better weather for outdoor activities, including campus construction projects, campus and rail line surveying, and extended trips to

⁶⁰ R.C. Carpenter, "Report of the Department of Engineering and Mathematics." *Fifteenth and Sixteenth Annual Reports of the Secretary to the State Board of Agriculture of the State of Michigan, September 30, 1876 and 1877* (Lansing: W.S. George & Co., State Printers and Binders, 1876 and 1877), 127-128, 69-73. Michigan State University Archives and Historical Collections. See also, Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 104-105.

⁶¹ R.C. Carpenter, "Report of the Department of Engineering and Mathematics." *Seventeenth Annual Report of the Secretary to the State Board of Agriculture of the State of Michigan, September 30, 1878* (Lansing: W.S. George & Co., State Printers and Binders, 1876 and 1877), 113. Michigan State University Archives and Historical Collections.

see construction projects. Carpenter focused his surveying classes primarily on the use of instruments, surveying rectangular plots, finding section corners, and finding old survey lines. His mechanics courses dealt mainly with mechanical powers, materials strengths, hydraulics, and pneumatics. Carpenter continued to fill his engineering classes with practical skills, such as construction techniques and farm machinery demonstration that would be most useful on the farm or in rural areas.⁶²

Total college attendance grew from 130 to 230 in the 1870s, and agricultural studies continued to dominate the curriculum. However, Carpenter taught all levels of students, and the number in his mathematics courses averaged nearly seventy students by the late 1870s. His surveying classes usually had over sixty students and his mechanics courses held steady in the low twenties. Before the full introduction of an engineering department in 1885, the number of civil engineering students peaked at 32 in 1879.⁶³

Though funding directly applied to engineering remained scant in the 1870s and early 1880s, and usually ran through the mathematics department first, engineering students did have access to a wide variety of journals and trade publications. President Abbot provided a full list of the library holding in his 1880 annual report. Noting that many of the sets were irreplaceable, he listed *Popular Science Review*, *Philosophical Transactions of the Royal Society of London* to 1872, *Smithsonian Transactions and Contributions to Knowledge*, *Nostrand's Engineering Magazine*, *American Architect*, along with several agricultural and

⁶² "Departments of Instruction" *Twenty-Second Annual Catalogue of the Officers and Students of the State Agricultural College of Michigan, 1878* (Lansing: W.S. George & Co., State Printers and Binders, 1878), 22-23, 32-34. Michigan State University Archives and Historical Collections.

⁶³ R.C. Carpenter, "Report of the Department of Mathematics and Engineering." *Eighteenth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, August 31, 1879* (Lansing: W.S. George & Co., State Printers and Binders, 1880), 40-42. Michigan State University Archives and Historical Collections. Carpenter listed the number of students in his annual reports. Madison Kuhn also detailed the total number of students and provided a degree separation in his histogram of the agricultural college enrollment. See "M.A.C. Enrollment 1857-1907." Kuhn Collection UA 17.107, Box 1141, Folder 126. Michigan State University Archives and Historical Collections.

chemical journals, and more social science oriented journals such as the *North American Review*, *Harper's Magazine*, the *Atlantic*, the *International Review*, and *Nature*.

Administrators and faculty prided themselves on a large set of quality journals, but they lacked a dedicated library until 1881 when the Library-Museum was built.⁶⁴

Manufacturing in Michigan took a new turn beginning in the 1870s and 1880s. In 1876, four Grand Rapids furniture manufacturers exhibited their products at the Centennial Exposition in Philadelphia. Easterners took an enormous liking to the Michigan craftsmanship, and new businesses quickly sprouted across the state, growing to 178 furniture factories and employing almost seven thousand workers by 1890. Carriage and wagon manufacturers also took advantage of the large lumber supply and transportation networks that Michigan afforded. Approximately forty communities supported 125 companies and over seven thousand carpenters and blacksmiths who constructed the vehicles. Though still heavily involved in agricultural pursuits, Michigan workers had begun to transition into more mechanical industries, requiring more skilled workers in wood and iron. Additionally, businessmen and manufacturers needed roads and railroads to move their goods, requiring civil engineers for surveying and mechanical engineers for the steam engines and materials engineering that drove and supported industry.⁶⁵

⁶⁴ T.C. Abbot, "President's Report." *Nineteenth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, August 31, 1880* (Lansing: W.S. George & Co., State Printers and Binders, 1880), 18-19. Michigan State University Archives and Historical Collections. Abbot requested money for a new library building in 1880. The library had moved around to available rooms as science laboratories were built between 1865 and 1875. Details of the first library building are given in the *First Biennial Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1881-1882* (Lansing: W.S. George & Co., State Printers and Binders, 1882), 39. Michigan State University Archives and Historical Collections. Specific details on library locations are provided in Keith R. Widder. *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 173-174.

⁶⁵ Willis F. Dunbar, *Michigan, A History of the Wolverine State*, 3rd ed., ed. by Georgy S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 401-405.

President Abbot and Professor Carpenter understood that the college needed to expand its engineering education efforts to meet the growing industrial demands of the state.

Carpenter's extensive work around the campus to improve the infrastructure and survey the farm for drainage and leveling provided a strong foundation for practical engineering work associated with agriculture and industry. His design and oversight of steam works and boilers for the campus supported mechanic engineering efforts. But Carpenter wanted more directed and systematic education for the classroom.

He began his efforts to improve the engineering curriculum in 1882 by requesting funding for a mechanical workshop. He emphasized the agricultural connections of engineering and farming by noting that farmers needed to develop technical skills, since they typically remained isolated from towns and cities where mechanical specialists could repair or develop machinery or parts. He noted that most of the other state agricultural colleges in the Midwest and East had mechanical workshops to instruct students in metal and wood working, and Michigan was in fact behind the curve on this development. He wanted Michigan's farmers to be "more independent" and give them the "ability to recognize good mechanical work." Carpenter knew the initial expenses would be large, but he justified the costs by explaining that student labor performed in the new shops would cover many of the expenses previously paid to outside contractors and workers. This student labor would also fit well with the mission of the college to educate the student in the classroom and in practical applications.⁶⁶

Carpenter received support for his workshop proposal from the students. Before his appropriation request had even gone to the state legislature, editors of *The College Speculum*,

⁶⁶ R.C. Carpenter, "Report of the Department of Mathematics and Engineering." *First Biennial Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1881-1882* (Lansing: W.S. George & Co., State Printers and Binders, 1882), 158-159. Michigan State University Archives and Historical Collections.

the college's first newspaper, called for alumni and friends of the college to "press their representatives" and "use their influence" to make sure the mechanical department was made a reality. First, the editors believed that the mandate of the 1862 Morrill land-grant bill required that the college teach mechanic arts, and the institution had never met the requirement and had been "losing ground" in this field. Second, the curriculum had become stagnant despite having one of the largest attendance rates in the nation for an agricultural college. Third, Carpenter planned to copy the Illinois Industrial University's plan of instruction (also known as the Worcester Method because of its origination at the Worcester Polytechnic Institute), which emphasized production of goods and machinery that could be sold for a profit. Fourth, and probably most influential, the editors noted that the state university had organized a small mechanical department and would "undoubtedly claim the appropriations" if the Agricultural College didn't act soon. The editors called for public support of the mechanical curriculum because they viewed it as "the greatest need of the institution" and a requirement to keep up with the expansion of educational opportunities of the times.⁶⁷

While mechanic arts had its supporters, the agricultural foundations of the college remained strongly influential. This dichotomy continued to plague the educational efforts and instructional directions of the college throughout its early years. Alumni wrote to the college newspaper on numerous occasions to throw their support behind the agricultural focus of the faculty and institutional programs. They praised the success of the college's plan to train farmers and return them to the farms and fields. They also wrote that where other colleges spent more on faculty and laboratories, Michigan's Agricultural College returned more

⁶⁷ *The College Speculum*, Vol. 1, No. 4 (1 June 1882): 52-53. Michigan State University Archives and Historical Collections.

farmers to the soil than any other. The alumni also expressed deep concern that adding engineering courses, classics, and other university style courses might bring in more students and “win a great name”, but they distracted from the aim to “flood the country with cultured farmers.” Critics believed the mechanical workers and agricultural laborers did not mix well, and that was the very reason an agricultural institution was “wisely created” and had to be maintained.⁶⁸

The two primary components of education supported by the 1862 Morrill Act faced off with each other at Michigan’s Agricultural College. Farmers wanted the college to remain an agriculturally oriented and dedicated institution. Industrialists and mechanics wanted to broaden the curriculum to encompass all the working classes and promote the development of engineering coursework that would supply the state with trained engineers and mechanics for industry and manufacturing. Despite these ideological differences, students crafted an image for themselves in the early 1880s that fit both groups. They recognized what they called “the true nature of men” by their work habits and demeanor, not their clothing and appearance. They believed that science, not the classics and ancient languages, brought tangible improvements to society and American culture. Though the role of manual labor, whether necessary for practical skill training, improvement and labor on the farm, or merely a distraction from classroom studies, was routinely debated by administration and faculty, students supported the benefits of manual labor and practical training as assets to the working classes. And the students consistently praised the value of broad knowledge with useful

⁶⁸ *The College Speculum*, Vol. 2, No. 7 (1 October 1883): 7-8. Michigan State University Archives and Historical Collections.

applications, as opposed to narrow, specialized training that left many workers shackled to dreary, repetitive jobs.⁶⁹

During this same time period, Rolla Carpenter continued to build up the engineering program within the mathematics department. He slowly acquired more surveying equipment, machinery models, and mechanical apparatus for the laboratory. He expanded the reference books and journals available to the students, adding journals on engineering, architecture, manufacturing, roads and railroads, and agricultural mechanics to the library's holdings. Carpenter also developed an agricultural engineering course and organized the shop work done by students, under the supervision of shop superintendent James Wiseman, to promote the completion of "useful constructions" which demonstrated competent skill knowledge while providing the college with machinery, models, and furniture.⁷⁰

Carpenter's efforts did not go unheeded. The installation of Edwin Willits in 1885 as the fourth college president heralded a new era in engineering education at the Agricultural College. Willits pushed through increased funding in a new appropriations bill that year,

⁶⁹ Students filled the college newspaper with short articles on character, education, and practical learning in the early 1880s, usually connecting themselves to one of the campus literary societies. For example, see Charles Grimes, "Theory and Practice in Life." *The College Speculum*, Vol. 2, No. 8 (1 June 1883): 4-5; A.C. Redding, "A Knowledge of the Classics not necessary to Culture." *The College Speculum*, Vol. 3, No. 1 (1 August 1883): 2-3, 10-11; R.J. Coryell, "Advantages of Special Studies." *The College Speculum*, Vol. 3, No. 3 (1 April 1884): 2; C.B. Collingwood, "Who is the Practical Man?" *The College Speculum*, Vol. 3, No. 4 (1 June 1884): 3-4; *The College Speculum*, Vol. 4, No. 2 (1 October 1884): 6-7; T.D. Hinebauch, "The Scientific Tendency of the Age." *The College Speculum*, Vol. 5 No. 1 (1 August 1885): 4. Michigan State University Archives and Historical Collections.

⁷⁰ "Departments of Instruction." *Twenty-Sixth Annual Catalogue of the Officers and Students of the State Agricultural College of Michigan, 1882-1883*. (Lansing: W.S. George & Co., State Printers and Binders, 1883), 27. Michigan State University Archives and Historical Collections. The catalogue listed Ferguson's *History of Architecture*, Works of Prof. Rankine, *Engineering* (London), Van Nostrand's *Engineering, Manufacturer and Builder*, *United States Engineers' Reports*, Gilmore's *Limes, Mortars, and Cements, and Roads and Pavements*, Gillespie's *Roads and Railroads*, Stephens's *Farm Implements*, Hatfield's *Carpentry*, Dirck's *Perpetual Motion*, Knight's *Mechanical Dictionary*, and Appleton's *Cyclopedia of Mechanics*. R. C. Carpenter focused on road care and construction, farm building construction, house drainage, sewage, and water supply, sewage disposal and utilization, highway bridges, limes, mortars, and cements, and farm implements in his Agricultural Engineering course. See R.C. Carpenter, "Report of the Department of Mathematics and Engineering." *Twenty-Third Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1883-1884* (Lansing: W.S. George & Co., State Printers and Binders, 1884), 49-53. Michigan State University Archives and Historical Collections.

effectively doubling and even tripling the amount of funds provided to departments.

Carpenter received \$17,000 for workshop equipment and mechanical department expenses.

The steam works for the campus got \$1400, and the math department made do with just \$450.

However, students received \$8000 in funding for labor performed on the farm and in the workshops, alleviating the hours of unpaid work they had been doing for several years under the auspices of “classroom study.”⁷¹

In his inaugural address, President Willits outlined the development of the college and its acceptance of the 1862 Morrill land-grant. He pointed out that the agricultural nature of the early college had necessitated more attention on farming than other studies, but it was time for that to change. He declared that in Michigan, the public needed industrial education. He had acquired funding for mechanical shops and noted that American industry had a great deal of catching up to do in order to compete with more established European businesses. Willits saw the limits of apprenticeship training as a form of technical training, and he emphasized that the future lay in theoretical instruction by technical schools. He wanted to take a capable man from the shop, give him instruction in drawing and design, mathematics and mechanics, practical training in the college workshops, and return him to the shop so that he would become more efficient and more capable in dealing with the business of industry. Willits heralded an age of “applied science,” where men “commanded the situation” who had an education in theory and practice which had been provided by the state and not by self-interested businesses.⁷²

⁷¹ “Correspondence 1885 - An Act to make an appropriation for the support of the State Agricultural College.” Edwin Willits Papers, UA 2.1.4, Box 868, Folder 1. Michigan State University Archives and Historical Collections.

⁷² Edwin Willits, “Inaugural Address, August 19, 1885.” Willits Papers, UA 2.1.4, Box 868h, Folder 7. Michigan State University Archives and Historical Collections.

Though the students and President Willits praised the educational aspects of the college and the advanced credibility of practical training to the business world, the realities of the engineering curricula remained decidedly working class. R.C. Carpenter gave his first report on the “Course in Mechanics Arts and Engineering” as a separate program in September of 1885. He had acquired numerous hand and machine tools for the students to practice on. He focused on wood and metal working, and designed the labor performed so as to produce “useful articles,” such as packing boxes, bench work, tool cases, and patterns for foundry work. He ambitiously intended to build future equipment for the shops, such as a small engine and engine-lathe.⁷³

Carpenter’s improvements in mechanics instruction paralleled the increased attention to technical and scientific instruction that students called for. Advocates noted the prosperity of the nation allied with a growing variety of occupations, especially in business and industry. The graduates of technical schools in the East seemed to fill all the positions of “trust and honor” in management and supervisory roles. Rather than maintaining the status quo of agricultural predominance for the college, engineering promoters noted the new demand for skilled workers in mechanical fields. Shop foreman, designers, bridge builders, electricians, architects, engineers of every stripe, and “practical scientific men” had become the preferred titles of middle-class America. The title of Farmer had begun to lose its luster, even in the agriculture west.⁷⁴

⁷³ R.C. Carpenter, “Course in Mechanic Arts and Engineering.” *Twenty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1884-1885* (Lansing: W.S. George & Co., State Printers and Binders, 1886), 88-89. Michigan State University Archives and Historical Collections.

⁷⁴ Paul Chamberlain, “The Needs of Technical Education.” *The College Speculum*, Vol. 5, No. 4 (1 June 1886): 1-2. Michigan State University Archives and Historical Collections. Chamberlain graduated in 1888 and went on to become the professor of mechanical engineering at Lewis Institute and later a consulting engineer. See Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 149-150. For an analysis of engineers and the working middle class see Robert Zussman, *Mechanics of the Middle Class: Work and Politics Among American Engineers* (Berkeley: University

The establishment of the specialized mechanic arts and engineering department at the Michigan Agricultural College sparked a dramatic rise in engineering students at the institution. In 1885, 270 students enrolled at the college. 250 of them focused on agricultural studies and only thirty registered as engineering students, though more than that took the mechanical courses. The next year, enrollment increased to 300 students and the number of engineering students had risen to eighty students. The number of agricultural students peaked at 240 in 1888 and proceeded to decline for the next twenty years. However, students in engineering studies steadily increased by an average of 15 students a year until 1893, and by an average of nearly 20 students a year until 1910.⁷⁵

Carpenter realized the increased demands on the new mechanic arts and engineering courses and shops immediately. In his 1886 annual report, he noted that the new lecture halls, completed in 1885 to house seventy students, were already overcrowded. He broke the students into two sections so that they would have enough room to work in the shop room. He requested \$3,000 to double that space and noted that soon more room would be required for the draughting and laboratory activities. Carpenter also asked for more tools, machinery, and greater power supplies for the expected increase over the next two years.⁷⁶

of California Press, 1985). On education and the new middle class of the late-nineteenth and early twentieth century see Burton J. Bledstein, *The Culture of Professionalism: The Middle Class and the Development of Higher Education in America* (New York: W.W. Norton & Co., 1976). On the rise of scientific management and the new factory system and worker see Daniel Nelson, *Managers and Workers: Origins of the Twentieth-Century Factory System in the United States, 1880-1920* (Madison: The University of Wisconsin Press, 1995). For an analysis of the decline in farmer status in the late nineteenth-century see Fred A. Shannon, *The Farmer's Last Frontier: Agriculture, 1860-1897* (New York: Farrar & Rinehart, Inc., 1945).

⁷⁵ "M.A.C. Enrollment 1857-1907." Kuhn Collection UA 17.107, Box 1141, Folder 126. Michigan State University Archives and Historical Collections. The last year numbers were provided for engineering studies was 1907, when total enrollment at the M.A.C. reached 1000. Kuhn carried agricultural student numbers up to 1912 because their number increased from a 1903 low of 225 students to a record high 610 in 1912.

⁷⁶ Edwin Willits, "Report of President Willets." *Twenty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1885-1886* (Lansing: Thorp & Godfrey, State Printers and Binders, 1886), xviii. Michigan State University Archives and Historical Collections.

Old prejudices and Carpenter's preference for the established nature of the college, rather than innovative solutions to over crowding, remained. He steadfastly supported his plan to accept only students with "predilections for industry." In this fashion, he could limit the number of students in the shops and also avoid taking students away from the agricultural courses. He did leave open the possibility that interested students might take a shortened course in shop work specifically designed for agricultural studies. But the facilities and faculty had limited resources and time, so the primary focus remained on the selected engineering students.⁷⁷

While Carpenter focused on furnishing his newly constructed work shops with woodworking and machine tools, other faculty worked to develop a fuller engineering curriculum. President Willits visited machine shops and manufacturers across the state of Michigan, promising that the college could provide their future workers with quality training beyond apprenticeship practices. He managed to persuade thirty-five students to enter the new course in mechanic arts and engineering. Lewis McLouth, the new mechanics and astronomy professor, put his efforts into studying curriculum programs that best suited Michigan's expanding agricultural college. McLouth had taught physical science at the Normal School in Ypsilanti for fifteen years and remained heavily involved in teacher training during his years at the Agricultural College. His philosophy of education leaned more towards the theoretical side, balancing out Carpenter's heavy dose of practical training and campus work performed by students.⁷⁸

⁷⁷ R. C. Carpenter, "Report of the Department of Mathematics and Engineering." *Twenty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1885-1886* (Lansing: Thorp & Godfrey, State Printers and Binders, 1886), xlviii-lij. Michigan State University Archives and Historical Collections.

⁷⁸ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 147.

McLouth remained open minded about how colleges structured new engineering programs. He spent much of his first year at the Agricultural College touring mechanical and industrial schools in the Midwest and East. McLouth attended the opening ceremonies of the Manual Training School of Toledo, Ohio, visited with the commissioner of education in Washington D.C. and studied the collections of the Smithsonian Institute, inspected the workshops of the United States Naval Academy, at Annapolis, and visited the Workingman's School and New York Trades Schools. He moved on to inspect the curriculum and skill training at the Stevens Institute of Technology, in Hoboken, New Jersey, the Worcester Free Institute, in Worcester, Massachusetts, and the Massachusetts Institute of Technology, in Boston. At all of these schools, McLouth carefully studied the curriculum, equipment, and shop work performed by students. He noted the successes and limitations of graduates and compiled a lengthy survey of his results for his annual report.⁷⁹

McLouth's recommendations for the future direction of engineering at the Michigan Agricultural College boiled down to two options. The supporters of the Worcester method of instruction, associated primarily with industrial schools and workingmen's institutes, relied on business oriented shops that produced marketable student work. The second group, mostly associated with colleges, insisted that "instruction rather than construction" guided the instructional program of the courses. The Worcester group claimed that students worked better if their efforts had some tangible value beyond practical exercise. The instructional group maintained that students could never compete with real production shops and that in

⁷⁹ Lewis McLouth, "Report of the Department of Mechanics and Astronomy." *Twenty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1885-1886* (Lansing: Thorp & Godfrey, State Printers and Binders, 1886), lv-lxii. Michigan State University Archives and Historical Collections.

order to perfect one skill a student's practical range became too narrowed. They also insisted that the student's instruction suffered for the sake of shop profits.⁸⁰

McLouth came down on the side of classroom learning and instructional work, pitting himself against the established practical methods Carpenter had relied on for years as the college developed its grounds and buildings. But McLouth didn't think the situation was untenable yet. He recommended maintaining a variety of machine tools, rather than a bank of similar lathes. He also suggested that branches of industry already practiced in Michigan had to be avoided by the college so that the school didn't compete with established businesses. But he suggested that new production methods or business ventures might be tried in order to promote development and secure funding for those new endeavors. He concluded that with careful considerations and management, not to mention substantial increases in state funding, the Agricultural College could continue building a quality engineering program.⁸¹

The establishment of a course in Mechanic Arts also ushered in a significant change in the general curriculum. With the addition of Lewis McLouth as the mechanics and astronomy professor, Rolla Carpenter and his brother Louis had more time for advanced mathematics courses. The engineering curriculum, which had remained largely unchanged since the late 1870s (though rearranged on several occasions) now experienced dramatic shifts and

⁸⁰ Lewis McLouth, "Report of the Department of Mechanics and Astronomy." *Twenty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1885-1886* (Lansing: Thorp & Godfrey, State Printers and Binders, 1886), lix-lx. Michigan State University Archives and Historical Collections.

⁸¹ Lewis McLouth, "Report of the Department of Mechanics and Astronomy." *Twenty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1885-1886* (Lansing: Thorp & Godfrey, State Printers and Binders, 1886), lx-lxii. Michigan State University Archives and Historical Collections. McLouth's specific recommendations included a two story addition to the shop, funding for a drawing instructor and shop superintendent, possibly from the Naval Academy, and funding for a personal assistant that could oversee the laboratory work associated with McLouth's courses. He also requested money for mechanical apparatus, gas generators for heating and lighting, a French and German instructor. McLouth concluded his report with a lengthy plea for specific organization and funding for women. He quoted that more than a dozen had begun taking mechanical courses and the number was expected to increase. They needed specialized instruction in domestic crafts, room and equipment for a woman's industrial laboratory, and an instructor and supplies for a model kitchen and dining-room in the proposed women's dormitory.

improvements. Engineering students took rhetoric, chemistry, botany, English, French, German, literature, and political science along with the rest of their classmates. The real differences showed up in the mathematics and engineering classes. Freshmen had courses in free-hand and mechanical drawing, algebra, geometry, and physics. Sophomores focused on mechanical drawing and completed courses in trigonometry, and experimental mechanics. Juniors had courses in analytical geometry and calculus, a major addition to the mathematics curriculum. Seniors took engineering, analytical mechanics, machine design, metallurgy, and civil engineering classes. In every term during the freshmen, sophomore, and junior years, students had some form of shop practice and training. Carpenter and McLouth, with the support of President Willits, had begun to systematically organize an advanced engineering curriculum that included advanced mathematics, specialized civil and mechanical engineering, and skilled practical shop work.⁸²

Students reacted to the curriculum changes in a variety of ways over the next few years. Agricultural studies supporters said that those students who focused on farming instead of the arts and sciences felt “tabooed and out of place.” They wanted the sciences to be taught in connection with agriculture, and they believed all students should be agricultural students at a college such as the Michigan Agricultural College. Supporters of the agricultural curriculum also endorsed a continuation of the manual labor requirement, which had come under fire from students in specialized sciences. Since the manual labor requirement provided for farm and garden work, many of the hours spent in the workshops didn’t count. The agricultural curriculum supporters felt the requirement provided one of the foundational

⁸² “Departments of Instruction.” *Catalogue of the Officers and Students of the State Agricultural College of Michigan, 1885-86*. (Lansing: Published by the College, 1886), 49-51. Michigan State University Archives and Historical Collections.

principles of the college and kept all students connected to the “true purpose” of the institution.⁸³

Students also expressed more optimistic outlooks on the changes. Some believed that the increased inclusion of sciences combined with practice benefited the agricultural programs. In his 1888 commencement speech, George Teller spoke of the importance of combining scientific principles and the practice of farming. Science, he said, “dissipated erroneous and superstitious beliefs,” thus eliminating chaos and chance. Science had eliminated the bear blight, a fungus that destroyed fruit while still on the tree, by finding the germ that existed inside and outside the fruit. Experiments improved planting methods and demonstrated the quality of some disputed wheat varieties. And he also applauded the growth of veterinary sciences at the college that taught anatomy and physiology since they kept “ignorant and inhuman quacks” from destroying domestic livestock. Teller recognized a fundamental relationship between science and practice that the Agricultural College staff had made a central part of their educational philosophy. Teller and his fellow students thought that by “promoting intelligence among farmers” and creating a fuller appreciation for the means and methods of agriculture, the college provided a sound basis for progress in the state and the nation.⁸⁴

⁸³ On the disagreement over specialization of coursework see *The College Speculum*, Vol. 6, No. 3 (1 April 1887): 8-9. On the support of manual labor see *The College Speculum*, Vol. 7, No. 1 (1 August 1887): 9-10. There was also disagreement over the increase in co-educational courses. Many of the agricultural and science courses designed for field and shop work had begun to either specialized for the engineers or broaden the topics to include domestic sciences. Those who didn't support the co-educational classes didn't want the women out of the college; they actually wanted more professors, more courses, and more accommodations for the female students. See R.C. Clute “Co-Education Would Be Detrimental to the College.” *The College Speculum*, Vol. 7, No. 4 (1 June 1887): 2-1.

⁸⁴ George Teller, “Science and Practice in Agriculture.” *The College Speculum*, Vol. 8, No. 3 (10 October 1888): 33-35. On the specialization of agricultural colleges using science see T.F. McGrath, “Agricultural Schools.” *The College Speculum*, Vol. 8, No. 4 (1 August 1888): 51-53.

The new inclusion of mechanic arts and the chance to broaden their knowledge and skills did gain considerable support from the students. A.E. Bulsun, an 1887 graduate, noted that knowledge of various subjects and skills resulted in far more business success and development than knowledge in one subject or pursuit. William Van Devort, an 1888 graduate, wrote enthusiastically in support of the mechanical courses and their balance of theory and practice. He disagreed with those who complained that the “allotted time for practical and shop work” didn’t allow a person to become a master mechanic and that that time might be better spent on books and theory. Van Devort believed the practical skills and applied construction knowledge of the mechanic made him far superior to the classically trained engineer, who often designed machines that could not be constructed or put together correctly.⁸⁵

The students’ support for improved mechanical coursework was matched by legislative support in 1887 and 1888. Carpenter, McLouth, and William F. Durand, who replaced McLouth in the engineering department in 1888, added a \$500 materials strength testing machine, two \$1500 boilers to the steam works, and over \$4300 in tools and machinery to the mechanical workshops. While the mechanics and engineering programs received over \$10,000 for their budget requests, the farm, horticulture, and veterinary departments received just \$7800, \$1000 of which went towards experimental work.⁸⁶

Since Carpenter, McLouth, and Durand oversaw the maintenance and improvement of the college’s infrastructure, many of their budget requests got eaten up by water, steam and building projects in the later 1880s. They did acquire nearly \$20,000 of the \$39,000 building

⁸⁵ A.E. Bunson, “A Wide Range of Knowledge is Essential to Success.” *The College Speculum*, Vol. 7, No. 1 (1 August 1887): 1-2. William Van DeVort, “Benefits of Mechanical Courses.” *The College Speculum*, Vol. 7, No. 2 (1 October 1887): 4-5.

⁸⁶ “Estimate of Appropriations for the State Agricultural College for 1887-1888 and Financial Records 1884-88.” Edwin Willits Papers, UA 2.1.4, Box 868, Folder 6. Michigan State University Archives and Historical Collections.

appropriation in 1888 for additions to the mechanics building, including added lecture hall space, offices, laboratories, and workshops. Carpenter also had to cover \$5000 for improvements and repairs in the steam works and \$3000 for improvements to the water works in 1887 and 1888, both of which served the campus and farm needs.⁸⁷

The Carpenter brothers, McLouth, and Durand all felt the strain of multiple demands on their time. In addition to campus and business contracts, they had to prepare lectures and oversee the shop and laboratory work of the students. Over the summer months, Carpenter had to supervise the repairs and improvements for the water, steam and drainage projects. Carpenter and McLouth put in significant hours designing, supplying, and requesting additional funds for the new mechanics buildings. Carpenter had arrived in 1874, spending every summer on campus improvements rather than laboratory work. McLouth had become the head of the engineering department in 1885, fully supported by President Willets' vision of fully embracing both aspects of the 1862 Morrill Act.

The work involved took its toll, however, and by 1890, all three men had taken advantage of new opportunities. McLouth left in 1887 to become the President of South Dakota State College. Louis Carpenter became the professor of engineering at Colorado State College in 1888, where he did work on hydraulic engineering and irrigation. Durand, a graduate of the Naval Academy and engineer for the fleet, distinguished himself with a short stint at the Worcester Institute before arriving at Michigan. His books and articles on ship propellers, marine engineering, fluid mechanics, and aeronautics allowed him to gain international prestige, and he moved on to positions at Cornell and Stanford beginning in 1890. Carpenter, one of the College's longest serving professors, took advantage of Durand's

⁸⁷ R. C. Carpenter, "Department of Mathematics and Engineering." *Twenty-Seventh Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1887-1888* (Lansing: Thorp & Godfrey, State Printers and Binders, 1888), 48-52. Michigan State University Archives and Historical Collections.

academic connections at Cornell and the notoriety of his own textbooks in experimental engineering, heating and ventilating, and work on internal combustion engines to obtain a position at Cornell in 1890 as well.⁸⁸

The significant turnover in the mathematics and engineering faculty were preceded by the election of Oscar Clute as president of the college in 1889. Edwin Willits was appointed as Assistant Secretary in the United States Department of Agriculture, where he took charge of coordinating the operations between the department and state agricultural and land-grant colleges and their associated experiment stations. Oscar Clute graduated from the Michigan Agricultural College in 1862 and served as a mathematics and surveying instructor until 1866. He had then entered the Meadville Theological Seminary and spent the next twenty years serving as a pastor in numerous Michigan communities. Many land-grant colleges elected religiously trained men to serve as president in their early years, and Michigan chose to hire one of their own for the position. This put the engineering department in the position of having an alumnus as president who understood the humble beginnings of the mechanic arts and engineering programs at an agricultural school.⁸⁹

Clute adhered to the founding principles put down by President Williams in 1857 as he began his own presidency. He focused on the development of the individual in “thought and action” to create a well-rounded farmer or worker who could competently approach any activity required on a modern farm or in a modern shop. Clute valued science as the fundamental element of knowledge to the working classes, just as Williams had. Clute recognized that the innovative advantage of the agricultural and land-grant colleges was the

⁸⁸ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 150-151.

⁸⁹ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 167-168.

creation of a system of instruction which taught both theory and applied skills. Workers “learned to observe, learned to think, and learned to learn.” Williams had broken with the traditional colleges to create a new educational philosophy, which by Clute’s presidency had gained the more official title of “New Education,” provided by Charles Eliot while he was at Harvard University in 1869.⁹⁰

Clute viewed American industrial arts as still in their infancy, and in direct competition with the established technical schools and industries of Europe. Artisans, according to Clute, could no longer know all that needed to be known to successfully promote their particular industry. Laborers only knew one job and had in essence become part of the machines they worked with, rather than skilled craftsmen who used tools to assist in their work. Clute wanted the mechanical department of the Agricultural College to go beyond simple shop training, to instruct engineers in the general scientific principles upon which industry was based. Students would then engage in laboratory and shop work to demonstrate the principles they had learned in the classroom. Put another way, Clute wanted graduates of the Agricultural College “to be able to express a fact or idea in words or by the product of skilled hands, guided by the disciplined brain.”⁹¹

Clute’s vision of science combined with practice in the laboratory gained favorable support from the mechanical and engineering faculty. Before he left for Cornell in 1890, William Durand began the movement of mechanical arts students towards more laboratory

⁹⁰ Oscar Clute, “Education at the Michigan Agricultural College: Its Scope, Methods and Results.” Clute Papers, UA2.1.5, Box 863, Folder 97: 1-5. Michigan State University Archives and Historical Collections. Clute spent the first five pages of his address summarizing the work of previous presidents and their philosophies of education. Charles Eliot published his educational philosophy in 1869, but it took decades for his plan and its terminology to trickle into the Midwest and South. See Charles Eliot, “The New Education: Its Organization.” *The Atlantic Monthly* (February-March 1869): 203-220, 358-367.

⁹¹ Oscar Clute, “Education at the Michigan Agricultural College: Its Scope, Methods and Results.” Clute Papers, UA2.1.5, Box 863, Folder 97: 7-10. Michigan State University Archives and Historical Collections. Clute spent the last eight pages of his address discussing the development of mechanic arts and the need to continue improving the training of engineers in both principles and skills through the use of laboratories.

experience. Freshmen and sophomore students continued to work in the wood and machine shops producing saleable goods. But Durand spent three hours per week with juniors and eight hours per week with seniors in the engineering laboratories. Faculty and students benefited from the addition of laboratory equipment designed for material strength testing, steam engine dynamics, air pumps, and test gauges. The shops did not suffer under Durand's direction. Wider lathes, cutter-grinders, drills, and wood shapers allowed students to produce better quality products in the wood shop. Durand left the shops and laboratories in better shape than he found them, and encouraged the Board to continue generously supporting the mechanic arts.⁹²

While the mathematics department enjoyed the stability Herman Vedder, a Cornell University graduate, brought for his thirty-four year tenure following Carpenter's departure, the engineering courses took a few more years to find their way. Lester Breckinridge, a graduate of Yale's Sheffield School, spent two years at the Michigan Agricultural College as the replacement for Durand before he left for the University of Illinois in 1893 and took the shop managers with him. Breckinridge focused on manual training during his short stay, to the exclusion of almost everything else. Vedder's oversight of the mathematics and civil engineering students provided the only check to Breckinridge's manual training methods.⁹³

In his 1892 report to President Clute, Breckinridge provided a lengthy appeal for more shop work with wood and iron. Breckinridge based his system of instruction on the physical surroundings of the individual, and what he saw in Michigan were woods and the beginnings of heavy industry. He firmly believed that drawing was the one classroom activity that

⁹² W. F. Durand, "Report of the Mechanical Department." *Thirtieth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1890-1891* (Lansing: Robert Smith & Co., State Printers and Binders, 1891), 41-43. Michigan State University Archives and Historical Collections.

⁹³ Madison Kuhn, *Michigan State: The First Hundred Years 1855-1955* (East Lansing: The Michigan State University Press, 1955), 150-151.

unfailingly instructed students in manual labor before they performed the actual activity, since students of all backgrounds and nationalities could understand it. Beyond this, Breckinridge called it “absurd to attempt to pound into one’s brain facts, knowledge, and learning.” He placed the students in the workshops, where “mind and hand” joined together to perform specialized skills. He stated that “Farmers and mechanics stand the test of scrutiny better than merchants. Civil engineers and architects are more competent in their professions than lawyers, judges and legislators.” He explained that his reasoning focused on the training of students rather than confining their education to “abstractions.”⁹⁴

Herman Vedder’s approach to teaching mathematics and civil engineering somewhat improved Breckenridge’s manual training methods. Vedder had a great appreciation of the principles and beauty involved with the study of “mathematical science.” However, he also understood that a subject needed to provide useful ends. He noted that geometry and trigonometry were most useful for the needs of mechanics and trade workers. Mathematics combined with physical sciences made possible “modern discoveries contributing to the health, wealth, and comfort of mankind.”⁹⁵

Vedder also insisted that mathematics trained the mind for mental discipline, and he carried this philosophy into his classroom and laboratories. Freshmen took geometry and algebra during spring, fall and summer semesters. Sophomores received instruction in algebra, trigonometry and extensive field practice in surveying during the fall and spring terms. Then in the summer, sophomores took classes in analytic geometry and differential calculus. Juniors took integral calculus in the fall, and courses in analytic geometry and

⁹⁴ L.P. Breckinridge, “The Educational Value of Wood and Iron Work.” *Thirty-First Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1891-1892* (Lansing: Robert Smith & Co., State Printers and Binders, 1892), 54-62.

⁹⁵ H.K. Vedder, “The Utility and Educational Value of Mathematics.” *Thirty-First Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1891-1892* (Lansing: Robert Smith & Co., State Printers and Binders, 1892), 128-134.

mechanics of engineering in the spring and summer. Seniors took a civil engineering course in the spring term. Vedder successfully maintained this mix of classroom instruction, field practice, and applied instruction in the classroom and laboratory (in the case of mechanical engineering) during most of his tenure at the Agricultural College.⁹⁶

Vedder could not completely balance the extreme nature of Breckenridge's manual labor program, nor could he completely adjust his educational program to the significant turnover in professors between 1888 and 1893. While he maintained well over one-hundred students in all of the mathematics courses, the number of engineering students, which had been on the rise since 1885, now began a small decline which lasted from 1890 to 1894. Though not as severe as the decline in agricultural studies, the drop signified the students' dislike of the switch to manual training instead of the a balance of classroom, laboratory, and shop work.⁹⁷

The decline in engineering turned around in 1893 with the arrival of Charles Weil, a graduate of the Massachusetts Institute of Technology. He took over the engineering department following Breckinridge's departure and provided leadership for the next thirteen

⁹⁶ H.K. Vedder, "Report of the Department of Mathematics and Civil Engineering." *Thirty-First Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1891-1892* (Lansing: Robert Smith & Co., State Printers and Binders, 1892), 127-128. Michigan State University Archives and Historical Collections.

⁹⁷ Vedder provided the total number of students enrolled for mathematics and civil engineering in each term; 175 for the fall, 128 for the spring, and 101 for the summer term. He noted that number provided did not indicate the daily attendance, which was considerably larger than the official enrollment. See H.K. Vedder, "Report of the Department of Mathematics and Civil Engineering." *Thirty-First Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, 1891-1892* (Lansing: Robert Smith & Co., State Printers and Binders, 1892), 127. Michigan State University Archives and Historical Collections. For the total number of enrolled students at M.A.C. and the leveling off/decrease of students from 1890-1894 see "M.A.C. Enrollment 1857-1907." Kuhn Collection UA 17.107, Box 1141, Folder 126. Michigan State University Archives and Historical Collections. President Clute provided a list of all the professors who had left the institution between 1888 and 1893 and what position they took after leaving in his ex-augural address. His main contention was that most of them had left for higher salaries. Thirty-two professors, two presidents and the college secretary comprised the list. Of the thirty two professors, thirteen were connected to science, mathematics, or engineering and sixteen had connections to agriculture, horticulture, botany, entomology, or veterinary studies. While a few of the thirty-four left to work for the department of agricultural, most of the professors left for jobs at other agricultural colleges, predominantly in western states. See O. Clute, "Bread, Brawn, Brain, and Four Years of Progress." *Baccalaureate Address and Ex-augural Address, 1893* (Lansing: Agricultural College, 1893), 30-31. Clute Papers, UA 2.1.5, Box 863, Folder 99. Michigan State University Archives and Historical Collections.

years. Vedder and Weil moved calculus into the summer of the sophomore year, so that more extensive coursework could be obtained in the junior and senior years. Students took more mathematically intensive courses in machine design, mechanical engineering, materials strength, thermodynamics, hydraulics, and electrical engineering. Where freshmen and sophomores spent eight to ten hours per week in the shop and only two in the laboratory, juniors and seniors typically spent 5-6 hours in the shop and eight to ten hours per week in the laboratory.⁹⁸

The installation of Vedder and Weil introduced eastern methods of engineering instruction and training that, combined with changes in the profession on a national scale, began a new era in engineering at the Agricultural College. Vedder and Weil brought in more advanced instruction and laboratory applications than their predecessors, simultaneously wedding the classroom instruction and applied training. Their systems of instruction and curricular changes helped shape the next several decades of engineering instruction at the Michigan Agricultural College.

Michigan's changing industrial base also shaped the future directions of engineering education at the Agricultural College. The success of carriage and wagon makers in Michigan led many of the businesses' most successful owners, such as William Durant, to begin dabbling in the new automobile business. By the 1890s, Henry Ford in Detroit and Ransom E. Olds in Lansing had begun to build automobile plants and required trained engineers to staff their design departments and run their factories. Entrepreneurs such as John B. Ford and Herbert Dow built chemical plants for salt and bromine production, requiring a new push for chemical engineers. The increased production of machinery and chemicals necessitated a

⁹⁸ "Departments of Instruction." *Catalogue of the Officers and Students of the State Agricultural College of Michigan, Thirty-Sixth Year, 1892-1893* (Lansing: Published by the Agricultural College, 1893), 38-39, 45-59. Michigan State University Archives and Historical Collections.

dramatic increase in mining production and better trained geologists and mining engineers. And by the turn of the century, electricity had become the power source of choice, meaning electrical engineers were in high demand.⁹⁹

The administration and faculty had undergone significant transitions beginning in the late 1880s and the new faculty faced increasingly sophisticated and rapidly changing state and national economies in the 1890s. The engineering faculty, comprised initially of Herman Vedder and Charles Weil, began the process of transforming the science and engineering departments to meet the engineering methods and skills required of the new and expanding businesses and industries in Michigan. They soon found that they would also need to meet the educational requirements of a growing society of professional engineers.

⁹⁹ Willis F. Dunbar, *Michigan, A History of the Wolverine State*, 3rd ed., ed. by Georgy S. May (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 404-442.

CHAPTER 4.

***NUMEN LUMEN* – ENGINEERING EDUCATION AT THE UNIVERSITY OF WISCONSIN BEFORE 1893¹**

The organization of the University of Wisconsin, and by extension the department of engineering, grew from state leaders' public and political desire to stand as equals with older and already established states. Just as in Michigan, the drive for early engineering education depended on the public's frontier identity and the perceived and necessary modernization of business and industry. However, the unique educational philosophy and emphasis promoted by state university officials, rather than agricultural college supporters, created a different path in Wisconsin for the refinement of engineering education.

The leaders of Wisconsin provided for a state university in the original state constitution of 1848. In Article X, Section 6, they stipulated that “a state university” be established “at or near the seat of the state government, and for connecting with the same, from time to time such colleges in different parts of the state as the interest of education may require.” By placing the state university near the state capital, legislators hoped that political debate and state growth would benefit from the proximity of college resources, what eventually came to be called the “Wisconsin Idea” by most scholars. They also hoped that proximity would allow politicians to more closely control the direction and management of the school. Unfortunately, their management, or mismanagement in many instances, of “proceeds, lands” and other funding which constituted the “university fund,” resulted in long term monetary struggles, slow growth, continuing administrative battles, and faculty turnover

¹ The University of Wisconsin official motto translates as “God, Our Light.” John Lathrop, the first University president defined it as “The Divine within the Universe, however manifested.”

rates that hampered curricular organization and instructional implementation in all subject areas.²

But philosophically, from the outset, the concept of service to the people and state guided the administration of the University. What eventually came to be known as the “Wisconsin Idea” had its origins in the early decades of the institution. The “Wisconsin System”, the direct precursor to university president Charles Van Hise’s Progressive Era “Wisconsin Idea,” came to full fruition in 1888 under the guidance of university president Thomas Chamberlain. The proponents of the “Idea” or “System” emphasized the value of a school that offered outreach programs and provided research on problems, concerns, and practices that were important to the state and its citizens. While agricultural research became the center for this Wisconsin public policy, engineering and mechanics training also promised to supply well-educated and practically trained individuals who could advance the states business and industrial practices.³

At the University of Wisconsin’s inaugural ceremonies in 1850, Regent board member Hyatt Smith provided several fundamental ideas to guide the University administration and faculty. Smith aimed to place Wisconsin at the “head of human progress” by sustaining and elevating national character and providing a uniform and equal system of education for all citizens. Underlying his reasons for the University programs lay the basic desire to elevate teaching, craft skills, mechanical ability, and even farming “to the dignity of a profession,”

² Jack Stark, *The Wisconsin State Constitution, A Reference Guide* (Westport, CT: Greenwood Press, 1997), 189-190. The “Wisconsin Idea” is a typical part of any Wisconsin state history. For example, see Robert C. Nesbit, *Wisconsin, A History* (Madison: The University of Wisconsin Press, 1973), 426-428, 437-438, 532-533; Richard N. Current, *Wisconsin, A Bicentennial History* (New York: W.W. Norton & Company, Inc., 1977), 191-193, 196-197; Vernon Carstensen, “The Origin and Development of the Wisconsin Idea,” *Wisconsin Magazine of History*, Vol. 39 (Spring 1956): 187; and Charles McCarthy, *The Wisconsin Idea* (New York: The Macmillan Co., 1912).

³ Jack Stark, *The Wisconsin State Constitution, A Reference Guide* (Westport, CT: Greenwood Press, 1997), 2.

and to provide an education in the arts and sciences equal to that of the “best colleges in the Union.”⁴

While addressing the gathering of state officials and public supporters, Smith highlighted the fact that Wisconsin’s population had quickly equaled that of Eastern states, attained comparable political status to the older states of the Union, and in his estimation would soon rival the political and economic importance of any other state in the Union. Smith wanted to boost the spirit of Wisconsin settlers, but his words were based in some fact. Wisconsin had quickly passed through its pioneer phase and by the 1850s, the state did have a vibrant and important role to play in the national economy, manufacturing, and business.⁵

Clearly, Smith had a great interest in promoting the intellectual and political influence that a high caliber state university might afford. But he also recognized the dire need for a strong, state system of public education which would support the agricultural and industrial sectors of the state. His call for raising the status of teachers to the professional level focused squarely on the inadequate supply and quality of common school teachers who instructed the working class citizens who engaged in farming, industry, and business. The University’s primary goal, according to Hyatt, should be to train and promote a large new class of professionally trained instructors who could then spread the necessary knowledge to the diverse citizens of the region. While he focused on the training of teachers, Hyatt also

⁴ A. Hyatt Smith, “Address on Behalf of the Regents.” Delivered at *The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 9-17.

⁵ A. Hyatt Smith, “Address on Behalf of the Regents.” Delivered at *The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 9-13. University of Wisconsin Archives.

promoted this as an indirect but important method of developing an educated and successful working class.⁶

Hyatt spoke on behalf of the Regents, expressing their hopes and ideas for the new University. John Lathrop, as the new chancellor of the University, spoke on behalf of faculty and program of study he proposed. The public expected a great deal from a man who had attended and taught at Hamilton College and Yale University, and led the University of Missouri for seven years. In his inaugural address, Lathrop promoted the idea that a university acted as the storehouse and disseminator of knowledge. Human progress, according to Lathrop, resulted from the democratic uplifting of society which only the university had the resources and ability to provide.⁷

But Lathrop discussed his ideas in general terms rather than specific actions, describing how chemists revealed the nature of elements and astronomers introduced new worlds and systems. Mechanics provided mechanisms and instruments which gave science its power and tamed the wilderness. The machinery of commerce “subdued the oceans and stimulated more abundant production.” Lathrop eloquently praised these endeavors, the pursuit of science, and the application of the arts. But in his opening address and subsequent governance of the university he never gave specific directions for what goals or methods faculty should promote, what exactly students should learn, and what benefits research and training at the University had to provide. He left his followers to ponder the notion that

⁶ A. Hyatt Smith, “Address on Behalf of the Regents.” *Delivered at The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 9-13. University of Wisconsin Archives.

⁷ John Lathrop, “By the Chancellor.” *Delivered at The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 19-30. University of Wisconsin Archives.

“progress flowed from accumulated knowledge, efficient systems, and intellectual application.”⁸

Lathrop did provide a few basic organizational recommendations in his 1850 speech. He proposed that a modern University needed departments of Science, Literature, Arts, and the Theory and Practice of Elementary Instruction. He appropriated this organizational structure from the Prussian and French systems of education, which he called “perfect” and the “progenitor of general culture and the popular mind” in those countries. In fact many educators, particularly at land-grant institutions gave high regards to European systems of technical education, particularly those systems they had seen in Prussia.⁹

On the subject of funding, Lathrop implored the Regents to dispense with the state allocated lands quickly and intelligently so that the money could go directly into buildings and grounds, books and equipment, and the hiring of quality faculty. Steadfastly interested in acquiring the necessary funds to operate the new institution, Lathrop also focused on developing an infrastructure and staff. The only instance in his address where he discussed how the new University could help apply knowledge to agriculture, business, or industry came with a request for “suitable demonstrations in Anatomy and Human Physiology, and well selected models illustrative of the useful and the fine arts.” Lathrop sought nothing more than models and diagrams to instruct University students on the applications of science and the mechanical arts, not asking for any other equipment or supplies or laboratory space.¹⁰

⁸ John Lathrop, “By the Chancellor.” *Delivered at The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 31-39. University of Wisconsin Archives.

⁹ John Lathrop, “By the Chancellor.” *Delivered at The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 40-43. University of Wisconsin Archives.

¹⁰ John Lathrop, “By the Chancellor.” *Delivered at The Inauguration of John H. Lathrop, Chancellor of the University of Wisconsin, at the Capitol, Madison, January 16, 1850* (Milwaukee: Sentinel and Gazette Power Press Print, 1850), 43-47. University of Wisconsin Archives.

As the Board of Regents undertook the actual organization of the colleges and faculty, engineering instruction became buried within the multiple duties of one professor generally responsible for mathematics, physical sciences, and astronomy. In Michigan and other states, supporters had relied on the state's colleges to enhance on-the-job training for mechanics and engineers needed to build the infrastructure of a frontier state. Wisconsin's political and University establishments focused on other areas in the 1850s. They created and funded the departments of science, literature, and arts, along with elementary instruction as proposed under the University charter. They also established faculty positions for "ethics, civil polity, and political economy," "mental philosophy, logic, rhetoric, and English literature," "ancient languages and literature," "modern languages and literature," "mathematics, natural philosophy, and astronomy," and "chemistry and natural history."¹¹

The Regents provided a broad and generalized description of the tasks envisioned for the professor of mathematics, natural philosophy, and astronomy. They listed this chair's duties as "instruction in pure and mixed Mathematics, Civil Engineering, Practical Surveying, and other field operations, Experimental Philosophy, and the use of apparatus, and Theoretic and Practical Astronomy." The Regents' implied structure in 1850 provided for only one professor, assisted by a small cohort of tutors, to instruct the students in the multitude of science studies as well as other fields.¹²

Despite the expansive duties and organizational limits placed on the mathematics and science department, the Regents intended to train new teachers in their university system who would have the ability to educate lower-level common school students in science and math as

¹¹ "Organization of the Collegiate and Normal Departments." *Second Annual Report of the Board of Regents of the University of Wisconsin, January 16, 1850* (Madison: David T. Dickson, State Printer, 1850), 6-8. University of Wisconsin Archives.

¹² "Organization of the Collegiate and Normal Departments." *Second Annual Report of the Board of Regents of the University of Wisconsin, January 16, 1850* (Madison: David T. Dickson, State Printer, 1850), 8. University of Wisconsin Archives.

part of a broad range of studies. The Regents explicitly listed courses in Algebra, Geometry, Surveying and Leveling, and practical applications of Chemical and Mechanical Science, along with elocution, mental, moral, and political philosophy. While organizers provided for mathematics and surveying courses within the departmental requirements in 1850, they made no mention of practical training for other applied sciences.¹³

The Regents left the door open to vocational and technical training at other institutions by providing an ordinance in the charter which directed the University Chancellor and Normal, or teacher training, professor to coordinate the University programs with other “educational agencies.” The board placed great importance initially on the relationship between University faculty and other state supported schools. They believed that future progress in “general culture” within the state, meaning improvements in business, industry, and most importantly intellectual ability, would depend on coordinated efforts between appropriately trained and equipped men and facilities. Their main intent focused on maintaining strict control of the state elementary and high schools. However, by the mid 1860s, the Wisconsin’s Legislators and University administrators had maneuvered to direct federal funding from the 1862 Morrill Land Grant Act into University coffers, essentially ending the possibility that schools other than the University could afford to offer vocational and technical training.¹⁴

¹³ “Organization of the Collegiate and Normal Departments.” *Second Annual Report of the Board of Regents of the University of Wisconsin, January 16, 1850* (Madison: David T. Dickson, State Printer, 1850), 8-11. University of Wisconsin Archives.

¹⁴ “Organization of the Collegiate and Normal Departments.” *Second Annual Report of the Board of Regents of the University of Wisconsin, January 16, 1850* (Madison: David T. Dickson, State Printer, 1850), 9-10. University of Wisconsin Archives. Ripon College and Lawrence University tried to acquire the 1862 Morrill Land-Grant funds, but University officials and legislators actually used the fact that state land-grant funds intended for the University had been mismanaged, to argue that they deserved to receive the funding to fulfill the mandate of the state constitution. Little analysis of this battle for funding and the early relationship between Wisconsin colleges exists in available scholarship beyond Richard Current’s state history volumes and Paul Wallace Gates’ study of the Cornell University pine lands. See Paul Wallace Gates, *The Wisconsin Pine Lands of Cornell University, A Study in Land Policy and Absentee Ownership* (Madison: The State Historical Society

In 1851, just a year after outlining their initial organization for the University that failed to offer any real vision for the applied sciences and engineering, the Board of Regents provided a much more explicit description for the “Application of Science to the Useful Arts.” Their reason for now including applied sciences and mechanics rested primarily on idea that Wisconsin was “destined to mature much more rapidly than even the most prosperous” of the new states. Also, the Regents realized that industrial development provided the quickest means for Wisconsin to grow into a robust, profitable, and dominant economy within the larger American economic system. They aimed to develop a “wisely constructed” general education system which would rely on science to “guide the hand of production and regulate the processes of trade.” And finally, the Regents made an early play for any future federal land-grants that might be specifically dedicated to useful arts and sciences, and which the Regents suggested would relieve the burden of educational costs from the state budget. Legislators wanted Wisconsin to grow industrially, not just rely on its agricultural base.¹⁵

The Regents provided rhetorical justification but not much detail in their program for applied sciences and useful arts. Their primary discussions of curriculum in 1851 revolved around the importance of agriculture and the ability of students in applied science programs to utilize university resources. They also promoted the idea that by attending the University, farmers and artisans could more readily attain the status of a professional by association with the school. But organizers felt the resources and University system needed to be consolidated into one, self-sufficient campus. Far flung agricultural and technical school would spread the

of Wisconsin, 1943); and Richard Current, *The History of Wisconsin: The Civil War Era, 1848-1873* (Madison: State Historical Society of Wisconsin, 1976).

¹⁵ “Application of Science to the Useful Arts.” *Third Annual Report of the Board of Regents of the University of Wisconsin, January 1, 1851* (Madison: Robert B. Wentworth, State Printer, 1851), 13-15. University of Wisconsin Archives.

funding, resources, and faculty to thinly, according to board members, decreasing the importance, and status, of the University graduates.¹⁶

Organizers also believed that a strong science curriculum would improvement the professional status of graduates, equipping them with reasoning skills and “modern knowledge” which could “level them up to the standard of professional dignity and consideration.” This reasoning also allowed the Regents to suggest that the University be enlarged to accommodate these necessary additions to the curriculum. They specifically called for adding chemical and mechanical science programs, an experimental farm, models of industrial processes and equipment, increased library funding, and additions to the natural science collection. While fully intending to provide a fuller curriculum which would benefit both classical and industrial students, University supporters effectively placed their institution at the vanguard of instructional and financial consideration in the minds of current and future legislators.¹⁷

While individually, the Regents’ justification and the Legislature’s funding took shape quickly in the 1850s, it took longer for the two plans to coalesce. Chancellor Lathrop supported the inclusion of agriculture and the useful arts. But he placed them right alongside the Law and Medicine departments as programs which would have to wait for future funding in order to begin instruction. The University curriculum did provide students with some rudimentary math, science, and engineering training in 1851, however. Freshmen completed algebra and geometry, sophomores completed trigonometry and surveying with instruments, and juniors began calculus with the introduction of mechanical applications. During the

¹⁶ “Application of Science to the Useful Arts.” *Third Annual Report of the Board of Regents of the University of Wisconsin, January 1, 1851* (Madison: Robert B. Wentworth, State Printer, 1851), 15-17. University of Wisconsin Archives.

¹⁷ “Application of Science to the Useful Arts.” *Third Annual Report of the Board of Regents of the University of Wisconsin, January 1, 1851* (Madison: Robert B. Wentworth, State Printer, 1851), 15-17. University of Wisconsin Archives.

second term, juniors took physics, hydrostatics, pneumatics, electricity, magnetism, and chemistry courses. Seniors completed optics, astronomy, mineralogy and geology. All told, four year students at the University of Wisconsin took thirty-eight different courses of which fourteen were directly related to science or mathematics. No manual labor or shop work hours existed as they did at agricultural or technical schools. Instead students attended “exercises” in translation, composition, forensic debate, and original oration. Despite the early administration’s support for agricultural and mechanical studies, students entered a system based on eastern models and run by classical scholars.¹⁸

Over the next several years, lack of resources prevented the administration and faculty from making any substantial advance in training for agricultural studies and the useful arts. Chancellor Lathrop continued to ask for funding to fulfill the “mandate of the college”, while limiting the actual growth of programs and faculty at the University until the requested funds actually arrived. As a result, John Sterling, professor of mathematics and natural philosophy, covered all mathematics and physical science courses during the entire first decade. In 1856, the University hired Ezra Carr, a graduate of the Rensselaer Polytechnic Institute in Troy, New York, and Castleton College in Vermont, where he earned his medical degree, to replace S.P. Lathrop who died in 1855. Carr taught agriculture, chemistry, and natural history and delivered additional lecture series on agricultural chemistry and the application of science to the useful arts. The Board report for 1856 noted that these lectures were “expressly designed for the young farmer and artisans of the state.” What the administration intended and hoped for was that these lectures would provide enough information for students who, as future teachers, would take the described applications into the common schools and local meeting

¹⁸ John Lathrop, “Report and Course of Study.” *Third Annual Report of the Board of Regents of the University of Wisconsin, January 1, 1851* (Madison: Robert B. Wentworth, State Printer, 1851), 3-6, 33-34. University of Wisconsin Archives.

places. In this way, advocates hoped that applied science knowledge could be disseminated, much like the program of county extension agents that would flow from agricultural schools in the coming decades.¹⁹

In 1857, Chancellor Lathrop recommended creating two additional departments: Civil Engineering, and Physics and Astronomy by the following year. Lathrop identified engineering as a distinct and dignified profession which continued to grow along with the industrial sectors of the nation. Lathrop specifically declared that the University should to provide the necessary training, for American youth right in Wisconsin, rather than requiring engineering students to go to European schools. He also located a division of “instructional labor” and practical skill training within the Physics and Astronomy department. Ezra Carr was given the duty of performing a state geological survey, and the new astronomy professor would make and record astronomical and meteorological observations, along with “other branches of physical enquiry.” Lathrop phrased his request in such a way that he left the duties vague, but explicitly stated his request for equipment funding. Engineering at the University of Wisconsin got off to an inauspicious start, but the University did lay a permanent claim on the engineering curriculum.²⁰

The administration and faculty had begun to make a few changes in the curriculum by the later 1850s. Students attended three terms instead of two, and the mathematics and sciences courses became more spread out. Students completed all of their mathematics

¹⁹ Early *Annual Reports* written by Chancellor Lathrop tended to be carbon copies of each other. Regarding the repeated requests for more funding see the *Fifth, Eighth, and Ninth Annual Reports of the Board of Regents of the University of Wisconsin, 1851-1857* (Madison: State Printers, 1852, 1856, and 1857), 8-11, 11, 20-25. University of Wisconsin Archives. On the original duties of Ezra Carr see John Lathrop, “Report.” *Eighth Annual Report of the Board of Regents of the University of Wisconsin, 1855* (Madison: Calkins & Proudfit, Printers, 1856), 10-11. University of Wisconsin Archives. For the background of early professors see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925* (Madison: University of Wisconsin Press, 1949), 177-184.

²⁰ John Lathrop, “Report.” *Ninth Annual Report of the Board of Regents of the University of Wisconsin, 1856* (Madison: Atwood & Rublee, State Printers, 1856), 22. University of Wisconsin Archives.

classes in the first two years and their entire science curriculum in the last two years.

Freshmen completed algebra and geometry, and sophomores completed trigonometry and began calculus. Juniors took mechanical philosophy and physics, which included hydrostatics, pneumatics, acoustics, and optics. Seniors took geology, mineralogy, chemistry, botany, and astronomy. Seniors could also take an optional course in agricultural chemistry.²¹

The course schedule did not list any specialized engineering course, but the faculty did describe how they addressed the subject in their departmental reports. John Sterling explained that engineering had been “attached” to his department through 1857, but he hoped that the forthcoming course reorganization would distribute subjects “more perfectly” so that his course load could become more realistically limited to mathematics and mechanical philosophy. Ezra Carr had expanded his curriculum in chemistry and natural history to include applied agricultural chemistry, laboratory analysis of soil, animal, and vegetable products, and scientific instruction in fertilizers. He also agreed to take over the organization of the Engineering program until an appropriate chair was hired. Initially, he laid out a curriculum of geometry, drawing, mechanical and physical applications, machine design, architecture and construction principles, and surveying. Though he was a specialist in chemistry, Ezra Carr envisioned a broadly-based approach to science and technical training curricula.²²

Despite Lathrop and Carr’s insistence on the importance of engineering, and Sterling’s pleas for a course load reduction, Lathrop reversed course in his funding requests in 1857. He continued to stress the importance of creating a distinct engineering department within the

²¹ “Subjects of Instruction.” *Ninth Annual Report of the Board of Regents of the University of Wisconsin, 1856* (Madison: Atwood & Rublee, State Printers, 1856), 52-53. University of Wisconsin Archives.

²² “Subjects of Instruction.” *Ninth Annual Report of the Board of Regents of the University of Wisconsin, 1856* (Madison: Atwood & Rublee, State Printers, 1856), 55-56, 60. University of Wisconsin Archives.

scope of the University curriculum, but now asked the Board of Regents to wait to hire a professor, since no instructional or laboratory space had been allocated in the current building plans. He did note that “when the proper time shall arrive” the University needed to be ready to implement the engineering curriculum.²³

Just a year later, in his final message to the Board of Regents, Lathrop again switched his reasoning and focus for the University. He stressed that “*professional or technical culture* stands as an investment for the individual,” and was best left to the individual enterprise. The State alone had the comprehension and means to provide the public with *general intellectual culture*, which Lathrop viewed as vital to the “full development of the man as an individual and member of the state.” In essence, Lathrop placed the importance of the University in providing a general education to the student, rather than providing specialized training in any professional or technical skill. Lathrop played to the Legislators’ policy leanings, while simultaneously incorporating his shifting educational philosophy. The faculty, students and public only saw his ambiguity and clear lack of direction for the new university²⁴

Poor management, legislative disagreement and posturing, and public disapproval led to dramatic changes from late 1857 to 1858. Administrators funded the University operations and buildings with loans from the state government, rather than proceeds from the sale of appointed land-grants, because the state refused to acquire suitable lands or gave funds to private colleges instead of the University. The growing debt created concern among legislators and the public alike about the continued viability of the University and its intended programs of study. The public also chaffed at the absence of agricultural and industrial

²³ John Lathrop, “Regents’ Report.” *Tenth Annual Report of the Board of Regents of the University of Wisconsin, 1857* (Madison: Calkins & Webb, Printers, 1857), 24. University of Wisconsin Archives.

²⁴ John Lathrop, “Chancellor’s Communication.” *Eleventh Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1858* (Madison: Atwood & Rublee, Book and Job Printers, 1858), 19-26. University of Wisconsin Archives.

education, and the refusal of the faculty to address their immediate needs in the “practical and useful arts.”²⁵

The Legislature appointed a joint committee to report on University affairs in 1857 and suggest recommendations for reorganization. They presented reports critical of specialized curricular expansion, low academic standards, and failure to provide practical training for teachers, farmers, engineers, and businessmen. While the Legislature refused to adopt the reports, the Regents and University administration did take action. The Department of Science, Literature, and Arts was expanded to include agriculture, commerce, engineering, and applied science. The University hired or re-appointed professors to cover the new curricula. Chancellor Lathrop, aware of public disapproval, worked with the Regents to persuade Henry Barnard, a leading figure in the public school movement and editor of the *American Journal of Education*, to accept the Chancellorship of the University. Lathrop left Wisconsin in 1858 to teach at Indiana University and shortly after that returned to the University of Missouri to teach and return to the position of President he had held before arriving in Wisconsin.²⁶

Henry Barnard did not accept his new position until January of 1859, and only spent a few months in the state during his two year term. D.W. Jones, the acting President of the University in 1858, and John Sterling, professor of mathematics and natural philosophy, and newly appointed Dean of the Faculty, began implementing programs which might build the University more quickly than Lathrop had wished. That year, Jones, Sterling, and the Regents restructured the Department of Science, Literature, and the Arts to include the schools of

²⁵ Merle Curti and Vernon Carstensen, “The University of Wisconsin: To 1925.” in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 6-7.

²⁶ Merle Curti and Vernon Carstensen, “The University of Wisconsin: To 1925.” in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 6-7.

Philosophy, Philology, Polity, Natural Science, Agriculture, and Civil and Mechanical Engineering. The administrators incorporated mathematics, practical engineering, architecture, drawing, natural history, general physics, physiology, hygiene, English language and literature, Latin, and two modern languages into the engineering studies curriculum.²⁷

The administration also restructured the curriculum and added professors. Freshmen completed algebra, geometry, and began trigonometry. Sophomores took surveying, navigation, and engineering, along with beginning calculus. Juniors took mechanical philosophy, physics, and spherical trigonometry. Seniors took theoretical and practical chemistry, botany, and physiology. To cover the specialized engineering and surveying courses, the University hired one new instructor, T. D. Coryell. Sterling and Carr promoted this revamped curriculum along two points of justification. First, they wanted to “fully prepare the student to discharge the active duties of the Surveyor and Engineer.” Second, they intended the engineering curricula to provide “discipline and strengthened mental faculties by rendering the instruction in the manner best adapted to the purposes of education.” Though this structure of training remained vague in 1858, the faculty made obvious overtures to the working classes with their engineering program by opening the door to practical education. Coryell provided more detailed explanations of the curriculum and practical training the following year, along with a continued argument for the essential job training that the engineering program was meant to provide to the new state.²⁸

²⁷ D.W. Jones, “Regents Report.” *Eleventh Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1858* (Madison: Atwood & Rublee, Book and Job Printers, 1858), 6-9. University of Wisconsin Archives.

²⁸ “Subjects of Instruction.” *Eleventh Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1858* (Madison: Atwood & Rublee, Book and Job Printers, 1858), 57-59, 64-65, 72. University of Wisconsin Archives. Coryell’s background or career after teaching at the University of Wisconsin has been lost with the destruction of University documents. Coryell did provide practical justification for the engineering program and a more detailed explanation of the engineering curricula once he had been at the University for a year. See T. D. Coryell, “Surveying and Engineering.” *Twelfth Annual Report of the Board of Regents of the*

The fluctuating number of faculty and students at the University during the 1850s testify to the public's unease with the school's direction and management. The number of faculty remained under ten until 1859, when more courses in applied science and agriculture began to be offered. Even then, the total size of the faculty only rose to twelve or thirteen until 1862. Student numbers remained steady at around forty students total at any one time from 1850 to 1855. Student enrollment rose sharply, up to 110 in 1856, coinciding with the hiring of Ezra Carr and the start of applied chemistry and engineering courses under his direction. Student enrollment dropped back to seventy in 1857, but rose back up to 110 in 1859 with the organization of the Civil and Mechanical Engineering school. Engineering and Agricultural Students made up 73% of the student population from 1859 to 1860, though total student enrollment dropped from a high of 112 students in 1859 to a low of 50 students in 1863 as a result of the Civil War. John Sterling stated in his faculty report for 1861 that a significant number of students had either dropped out to join the army, never enrolled because they "felt constrained to become soldiers," or remained at home because another family member had enlisted. The University rebounded in 1863, enrolling 250 students, most of whom had been released from the army or from family obligations. Just a year later, student enrollment reached 361, split evenly between men and women. Most of these students took advantage of the normal school curricula, with just 28 students enrolled in science, agriculture, and engineering.²⁹

University of Wisconsin, September 30, 1859 (Madison: James Ross, State Printer, 1859), 68-70. University of Wisconsin Archives.

²⁹ The University began providing student enrollment numbers in 1859, but the most useful data came from the 1887 junior class magazine. See "Graphic Statistics of the University, 52'-86'." *Trochos*, February 1887 (Madison: Published by the Junior Class of the University of Wisconsin, 1887): 22-23. University of Wisconsin Archives. For Sterling's report see "Appendix C." *Fifteenth Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1862* (Madison: Smith & Cullaton, State Printers, 1862), 15. University of Wisconsin Archives. The first specific count of men and women came in 1864. Women, who had been officially barred from the University since it opened, had been enrolling in normal school classes since 1852,

The public's unease with the University, and the relatively low number of students in the 1850s and early 1860s, reflected both the nature of a frontier state and disconnect between the state's industries and the school's educational emphasis. The primary industries Wisconsin citizens engaged in by the mid-nineteenth century were lumber and wheat processing, agriculture and related implement construction, and a limited amount of mining. Between 1850 and 1860, the number of skilled workers increased from 6,000 to 17,000 workers. The lumber industry alone increased from 1,500 workers to over 5,000. Flour mills went from 400 to over 1,000 employees. Agricultural industries more than doubled, from 500 to 1,200. And mining had a small gain from 300 to 500 workers. While educators constructed a state university focused on humanities and a limited number of science classes in the 1850s, the population of the state was engaged in frontier development that depended on agriculture and basic manufacturing.³⁰

The new University in Madison offered even less to the state's growing transportation industry. Shipping companies had firmly established themselves on the rivers during the fur trade and built sizeable fleets that supported the state's early agricultural development. Once agriculture and supporting settlements moved into the interior of the state, roads and railroads

though their numbers were never calculated. Beginning in 1863, and especially after the Civil War, they were allowed to enroll "through the back door" of the normal school curriculum. For enrollment numbers and the opening of the curriculum to women see the *Seventeenth Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1864* (Madison: Smith & Cullaton, State Printers, 1864), 2. University of Wisconsin Archives. For a brief analysis of Civil War withdrawals and women at the University of Wisconsin see Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925." in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 10-11. The faculty provided a detailed report of the University's failures during the Civil War in an 1865 report to the Regents. See "Difficulties and Embarrassments of the War Period." *Eighteenth Annual Report of the Board of Regents of the University of Wisconsin, 1865* (Madison: William J. Park, State Printer, 1865), 21-22. University of Wisconsin Archives. Curti and Carstensen provided a more detailed look at the early years of enrollment in *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1949), 116-119.

³⁰ The data for various industries was compiled from the *Manuscript Census for the State of Wisconsin, 1850 and 1860*, in Margaret Walsh, *The Manufacturing Frontier, Pioneer Industry in Antebellum Wisconsin, 1830-1860* (Madison: State Historical Society of Wisconsin, 1972), 18-22.

became necessary. The railroad companies rapidly expanded across the southern end of the state by 1860, connecting Lake Michigan with the Mississippi River. However, the managers and engineers responsible for this construction typically had little or no training and learned on the job. The poor management and limited engineering skill resulted in only 600 miles of track and a nearly 100% default rate by 1857, when an economic downturn hit the region. Investors quickly turned the situation around in the 1860s, supported by a strong economy and state and federal grants. By 1860, over eight rail lines traversed the southern end of the state and at least three companies had reached the northern portions of the state. After 1870, more than twelve different railroad companies operated over 10,000 miles of railroad lines throughout the state.³¹

Wisconsin settlers found themselves in a setting overflowing with natural resources. While labor was in relatively short supply, the influx of immigrants between 1850 and 1870 allowed enterprising businessmen to make a lot of money with little capital outlay or training. Unskilled workers or those with agricultural backgrounds could easily engage in the lumber industry or successfully manage to grow a productive wheat crop. Numerous farm-machinery industries, including J.I. Case Company and International Harvester, benefited from the combination of good land and strategic transportation systems. But farming and manufacturing in the early frontier days of the state depended on ambitious entrepreneurs and a steady influx of laborers. People engaged in agriculture and industry simply did not need or want scientific research or professional engineers to improve what was already a good thing.

³¹ William F. Raney, *Wisconsin, A Story of Progress* (New York: Prentice-Hall, Inc., 1940), 179-196. See also, Robert C. Nesbit, *Wisconsin, A History* (Madison: The University of Wisconsin Press, 1973), 190-207.

And even if they did, the University had no programs to produce them in the 1850s or 1860s.³²

In Iowa and some other states, supporters of agricultural colleges and state universities used the passage of the 1862 Morrill Land-Grant Act to catapult their state schools into the forefront of agricultural and engineering studies. Legislators and administrators in Wisconsin stumbled in this regard. The Legislature accepted the grant in 1863, but it took three more years before they formulated an acceptable plan for the funds. Various factions campaigned for their preferred institution: the University in Madison, Ripon College in Ripon sixty miles northeast of Madison, Lawrence University in Appleton thirty miles southwest of Green Bay, and a small group asked for a completely separate agricultural college. Supporters for Ripon College and University faced off over funding distribution and increased financial burdens for Dane County on one side, and public funding priority on the other. The debate garnered very little attention in the state newspapers, overshadowed by the second railroad land grant. Agricultural and engineering students had to suffer through political wrangling, inadequate and slow application of funding, and vague organizational mandates from the legislature and University administrators.³³

State legislators eventually settled on giving the Morrill funds to the University. Lobbying efforts by University supporters won over many politicians, but it was also the easiest and most visible way to consolidate the state's higher institutions of learning into one

³² Robert C. Nesbit, *Wisconsin, A History* (Madison: The University of Wisconsin Press, 1973), 180-182.

³³ W. H. Glover, *Farm and College, The College of Agriculture of the University of Wisconsin, A History* (Madison: The University of Wisconsin Press, 1952), 28-29, ff 12-16. Glover cited the *Milwaukee Sentinel* and *Ripon Commonwealth* as the only two papers that discussed the Morrill Land-Grant appropriation. The most complete discussion of the agricultural department is found in W. H. Glover, "The Agricultural College Lands in Wisconsin." *Wisconsin Magazine of History*, Vol. 30 (March 1947): 261-272. An extensive examination of early funding, state land grant appropriations, and the political debates that surrounded them are covered in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 120-152, 296-326.

system. They also included a reorganization of the University, new courses in math and science, and applied uses for science and the “economic arts.” However, they only asked that the curriculum be expanded as income permitted, making the new agricultural and mechanic arts endeavors of the University completely dependent on the management and sale of the new federal lands. While Cornell University had managed its federal lands in a manner which maximized their income, Wisconsin politicians moved quickly to sell the lands at a fixed price of \$1.25. This meant the agricultural and mechanic arts schools would only gain a portion of the expected \$300,000. Legislators and Regents remained vague on what they actually wanted from the agricultural and mechanic arts programs, further hamstringing the development of those programs in the 1860s and 1870s.³⁴

The reorganization of the University in 1866 by state legislators gave greater emphasis to science and mechanical or applied arts. The 1866 Reorganization Act focused on applied sciences and professional endeavors. Section one stated that “the object of the University shall be to provide the means of acquiring a thorough knowledge of the various branches of learning connected with the scientific, industrial and professional pursuits.” Section two stated, “the college of arts shall embrace courses of instruction in the mathematical, physical and natural sciences, with their applications to the industrial arts, such as agriculture, mechanics and engineering, mining and metallurgy, manufactures, and architecture and commerce.” Along with the restructuring of the Board of Regents, the University’s faculty

³⁴ W. H. Glover, *Farm and College, The College of Agriculture of the University of Wisconsin, A History* (Madison: The University of Wisconsin Press, 1952), 28-29. For further analysis of Cornell University’s management of federal lands in Wisconsin see Paul Wallace Gates, *The Wisconsin Pine Lands of Cornell University, A Study in Land Policy and Absentee Ownership* (Madison: The State Historical Society of Wisconsin, 1943).

now had a new mandate to focus on skill training and curricula which promoted the industrial progress of the state.³⁵

Despite politicians' mandates, engineering students encountered two difficulties under the reorganization. First, faculty and students had very little practical equipment for skill training in civil and mechanical engineering. Second, T. D. Coryell left the University and administrators did not replace him or reassign his courses. Most of the scientific equipment faculty had at their disposal consisted of classroom demonstration apparatus, glassware, undergraduate laboratory pieces and measuring devices, and a few odd electrical and optical components. Faculty had no research quality equipment and students had no shop or workshop equipment to work with. The extent of engineering related equipment available to faculty and students consisted of one surveying transit, a leveling rod, one surveyor's compass, twelve sets of drawing instruments, one steam engine, and a set of illustrations for a low pressure steam engine. With the departure of Coryell, Sterling's continuing oversight of administrative duties in the absence of a University president, and the expansion of Carr's chemistry and agricultural duties, engineering ceased to exist as a distinct program at the University. Beyond practical surveying, students only had practical coursework in chemistry and agriculture.³⁶

³⁵ "Chapter CXIV – General Laws of 1866: An Act to Reorganize and enlarge the University of Wisconsin." *Nineteenth Annual Report of the Regents of the University of Wisconsin, September 30, 1866* (Madison: Atwood & Rublee, Book and Job Printers, 1866), 3. University of Wisconsin Archives.

³⁶ "Class III. – Personal Property in University Buildings." *Nineteenth Annual Report of the Regents of the University of Wisconsin, September 30, 1866* (Madison: Atwood & Rublee, Book and Job Printers, 1866), 21-24. University of Wisconsin Archives. The annual report listed Paul Chadbourne as the new president, John Sterling as Professor of Natural Philosophy and Astronomy, and Ezra Carr as Professor of Chemistry and Natural History. R. E. Harmon and Amos Thompson were listed as tutors. The report of the Regents also stated that they hoped to fill vacant positions as soon as possible, but gave no time line for such additions. Faculty did not even bother listing engineering in the departmental reports. See Edward Salomon, "Report of the Regents." *Twentieth Annual Report of the Regents of the University of Wisconsin, September 30, 1867* (Madison: Atwood & Rublee, Book and Job Printers, 1867), 2-14. University of Wisconsin Archives.

It was not until after 1867 that the University's reorganization, combined with a series of administrative hires, led to significant changes in the faculty and in the engineering curriculum. The Regents' first new hire was Paul Chadbourne, a professor of natural History at Williams College and initial selection for the presidency at the newly selected Massachusetts State Agricultural College at Amherst. Upon arriving in Wisconsin, Chadbourne supported the sciences and appointed several new science professors to support the 1866 Reorganization Act. William Daniels, a graduate of and instructor at Michigan Agricultural College brought his Midwestern farm background and extended training at Harvard's Lawrence Scientific School to bear on the chemistry and agricultural programs. John Davies took over physics courses, and Roland Irving covered geology, but no engineering instructors came to the University during Chadbourne's presidency. His belief that practical training and liberal studies conflicted with one another at state supported schools lay at the foundation of his administrative decision to focus on literary and theoretical science improvement over applied sciences and useful arts.³⁷

Chadbourne outlined his educational philosophy in an 1869 article for *Putnam's Magazine*. Chadbourne praised the efforts of administrators at industrial schools to provide a new platform of education to improve manual labor. He also applauded the efforts of older colleges to expand their educational offerings to address the needs of the public. However, he warned that many colleges of both types would fail by trying to do too much. Old colleges had started to introduce agriculture, practical chemistry, mining, engineering, and similar

³⁷ Paul Chadbourne and his newly appointed faculty hires were listed in 1869. See "Annual Report." *Twenty-Second Annual Report of the Regents of the University of Wisconsin, September 30, 1869* (Madison: Atwood & Rublee, Book and Job Printers, 1869), 3-4. University of Wisconsin Archives. Descriptions of Chadbourne's education and administrative successes and failures can be found in Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925." in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 12-14; and in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*. Vol. 1 (Madison, University of Wisconsin Press, 1849), 218-235.

studies in order to maintain student enrollment levels. New industrial colleges, especially those supported by the 1862 Morrill Land Grant Act, had a mandate to cover these fields, but their administrators also tried to cover liberal studies to enhance the prestige of the new colleges and raise them to the level of the established schools. Students could patch together the same education at either kind of school, negating the reason for having distinct systems and schools. Chadbourne admonished the schools for wasting the resources of the state with this duplication. He concluded that each school needed to confine itself to its specific field and that the faculty at the industrial schools had the best placement for improving scientific knowledge. Chadbourne insisted that school administrators needed to have greater control over their institutions, rather than allowing state legislators to use the schools as political tools.³⁸

Chadbourne tried to adhere to his philosophy of promoting theoretical over applied science while at the University of Wisconsin. He praised the scientific endeavors of faculty and the enthusiastic reception of science courses by students. Chadbourne focused on agriculture, chemistry, and biology, primarily because engineering had no instructor and what engineering studies did remain had been placed in the military tactics curriculum. Students still had access to civil and military engineering as seniors and graduate students in 1869, but the military curriculum focused primarily on “practical instruction in the Schools of the Soldier, Company and Battalion and Dismounted Cavalry.” Students spent their time with

³⁸ P. A. Chadbourne, “Colleges and College Education.” *Putnam's Monthly Magazine*, Vol. 14, No. 21 (September 1869): 335-342.

drill practice and learning regulations. They had little time for practical engineering studies by the end of the 1860s.³⁹

Chadbourne supported expansion and reorganization in multiple areas, but didn't completely support the curricular direction of the school which avoided agricultural instruction. He took the opportunity to show Wisconsin's particular monetary failures with regards to the federal land-grant funding, money which was supposed to support agriculture and mechanic arts. He noted that state universities typical fell short of the educational mandate while specialized agricultural schools tended to provide much better applied instruction. 1869, Iowa had a yearly income of \$30,000 for the Agricultural College. Michigan had almost the same amount. Wisconsin had an average income of less than \$2,000 annually over the three years between 1866 and 1869. The funds for analytical laboratory, scientific equipment, applied science instruction, and military instruction had all come from the general University's funds, rather than the Morrill Act appropriations. Chadbourne felt completely vindicated in his admonishment of Wisconsin's educational system. Students did not benefit from the land-grant funds because what little money the state acquired from the selected lands never got into the hands of professors and instructors who taught sciences, mechanic arts, or agriculturally related studies.⁴⁰

Chadbourne accepted the presidency of Williams College in early 1870. Despite his criticism of the University of Wisconsin and system of education, he remained popular for his efforts to improve the University under the reorganization plan. John Sterling finished out the school year, and the Regents finally settled on Reverend John Twombly, a Methodist minister

³⁹ "The College of Arts." *Twenty-Second Annual Report of the Regents of the University of Wisconsin, September 30, 1869* (Madison: Atwood & Rublee, Book and Job Printers, 1869), 9-15, 24-25. University of Wisconsin Archives.

⁴⁰ "The College of Arts." *Twenty-Second Annual Report of the Regents of the University of Wisconsin, September 30, 1869* (Madison: Atwood & Rublee, Book and Job Printers, 1869), 8-9. University of Wisconsin Archives.

and known for his fund-raising efforts. But Twombly misrepresented himself and made no friends at the University. Faculty felt he had little tact or culture. Students initially tolerated his paternalism and evangelical fanaticism, but quickly turned against him once his classroom performance showed no promise. The Regents felt bullied by his insistence that he be given a seat on the board. By January 1874, the Regents voted to remove him and Twombly resigned. The very same day, the Board elected John Bascom of Williams College to fill the vacancy.⁴¹

Though Twombly's term as President was as short as Chadbourne's, and decidedly less popular, engineering did make progress during his administration. The Board established a Department of Civil Engineering during the 1870 annual meeting. Colonel Walter S. Franklin, a graduate of the Harvard Scientific School, took charge of the military and civil engineering courses beginning in the fall of 1870, though he didn't remain past his first year. Students had courses in drawing, geometry, theoretical and practical mechanics, civil engineering and use of surveying equipment, stone cutting, and railroad engineering. While still basic in its program of study, the Board saw a larger purpose for the department. They noted that the courses provided only an outline of the necessary studies, but that after a "moderate amount of practice in the field" a student could "fill the higher positions in the profession." The board realized the engineering curriculum did not provide full training for employment, so they expected students to select courses from other departments, with the help of a faculty advisor, which would "furnish them with full employment." Students had

⁴¹ Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925." in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 14-15.

access to a limited program of engineering training, but not enough to enable them to fully pursue engineering of any kind as a career.⁴²

Businessmen and manufacturers did not rely on the University, or even support its mission by the 1870s anyway. The frontier industries of lumbering, agriculture, and supporting manufacturing endeavors still dominated the state's economy. The great change people encountered from earlier decades were a rush of business consolidations in the 1870s and a period of economic diversification that lasted well into the 1890s. As the frontier pushed westward into Iowa, Minnesota, the Dakotas, and Nebraska, the lumber industry had to find new methods for transporting its product to other states. Essentially, this meant investing in western railroads both within Wisconsin and in western territories, and new mills downstream. The smaller business owners simply could not compete, and skilled labor traveled away from the population centers as the railroads and mills pushed westward and to the south.⁴³

As wheat farms grew larger and pushed into new frontier states to the west, a similar problem occurred. Small family farmers were bought out by larger cooperatives who could afford the expensive machinery and pay laborers instead of relying on traditional planting and harvesting methods. Displaced lumbermen either moved into northern mining operations or switched to agriculture. Farmers began to diversify into market crops and dairying. However, the skill and training involved in these businesses remained an ad-hoc affair. Where agrarian discontent rose and farm and labor organizations elsewhere tended to look to the state university or agricultural schools for support in their individual states, in Wisconsin

⁴² "Department of Civil Engineering." *Twenty-Second Annual Report of the Regents of the University of Wisconsin, September 30, 1870* (Madison: Atwood & Culver, State Printers, 1870), 10-11. University of Wisconsin Archives.

⁴³ William F. Raney, *Wisconsin, A Story of Progress* (New York: Prentice-Hall, Inc., 1940), 206-215.

they focused primarily on political action for improved conditions, rather than practical application and development. The lack of funding and limited training services afforded by the University in the 1870s and early 1880s did not offer graduates or the public much in the way of opportunity either. Despite the tenuous relationship the University faculty had with politicians and the public, they did recognize that they had to find a way to gain more popular support and offer something of value to the working class citizens of the state.⁴⁴

Major William Nicodemus, a graduate of the United State Military Academy at West Point, took over the military and engineering department in the summer of 1871. He reorganized the curriculum of both programs, providing greater autonomy for the engineering students from the military instruction. Nicodemus began the process of getting European instruments and models for teaching engineering. He also added courses for building materials and structures, prime movers, mineralogy and geology, metallurgy, bridges, assaying, water engineering, and an elective in science language to the curriculum that Franklin had overseen. He required graduation theses for seniors and provided practical training in the use of instruments, laying out railway curves, and preparing drawing and specification projects of machines and structures. Nicodemus started with extremely limited resources and a fragmented system of instruction. Within a year he had organized greater consistency for the students in both the classroom and in the field.⁴⁵

John Bascom, an eclectic scholar of theology, law, humanities, social sciences, and natural sciences, arrived at Madison in the late summer of 1874 from Williams College to take over Twombly's teaching and administrative duties. He commented on his own shyness

⁴⁴ William F. Raney, *Wisconsin, A Story of Progress* (New York: Prentice-Hall, Inc., 1940), 241-260.

⁴⁵ "The College of Arts – Department of Civil Engineering and Technical Courses." *Twenty-Third Annual Report of the Regents of the University of Wisconsin, September 30, 1871* (Madison: Atwood & Rublee, Book and Job Printers, 1871), 17-18, 33-34. University of Wisconsin Archives.

and self-judgment upon arriving at the University, which ultimately explained his detached and cold handed style of leadership. He championed the obligation of the government to protect and serve the interests of farmers and workers, but allowed very little input from professors and ran the school almost single-handedly. The only matters of administration he didn't oversee personally were controlled exclusively by the regents; faculty recommendation approval, permission to leave campus, approval of courses, textbooks, and degrees, and student discipline. Though his tenure lasted over twelve years, repeated conflicts with the members of the Board of Regents led to constant financial bickering and disagreement over who actually ran the affairs of the school. However, his most significant contribution to the University's educational philosophy lay in his strong support of "harmonizing" new methods of mathematics and science with the humanities, especially religious studies.⁴⁶

Despite their differences, the Board of Regents and Bascom did concur on the importance of practical education and the application of mathematics and the sciences to the industrial arts. George H. Paul, the president of the Board of Regents in 1875, stated that the University courses of instruction "properly developed and applied, are by no means limited in their object to a merely theoretical education. They refer as well to the practical and economic pursuits of daily life, and relate to the development of those mineral, agricultural and manufacturing industries which constitute the main sources of our material wealth." Both parties desired adequate funding for specialized buildings, well-trained faculty, and supported

⁴⁶ Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 15-20. For a more detailed study of Bascom's tenure as president and his intellectual leanings see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 246-295.

an emphasis on producing graduates that contributed to the economic improvement of the state.⁴⁷

By the mid-1870s, administrators made sure their message of intending to turn out practically trained students reached the public. University catalogues, Regents reports, and even press releases to the student newspaper highlighted the functionality of engineering training. The University “embraced” the civil and mechanical engineering program of study, where the “object of the department is to give students instruction in theory and practice” so that after a prescribed amount of field work, they could “fill the most responsible positions in the profession.” To alleviate any criticism of the balance of classroom study and field work, the faculty wrote into their course description that “Great stress is laid upon the proper use of instruments and as much time as possible is devoted to field practice.” They had to reassure the public that the students would return to the farms and smaller communities of the state, rather than simply rushing to the cities for opportunities with bigger industries or traveling west with the expanding railroads.⁴⁸

Just six years later, the University had massaged its message concerning the practical nature of engineering instruction at the institution. The object of the engineering department was now to “fit students for the profession of Civil and Mechanical Engineering.” And rather than stressing practical field work, “Those wishing to take the requisite time will have opportunities afforded them in the machine shop to acquire the use of tool and gain mastery of general principles.” University personnel still recognized the importance of a practical

⁴⁷ George H. Paul, “Annual Report to the Governor.” *Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1875* (Madison: E.B. Bolens, State Printer, 1875), 3-9. University of Wisconsin Archives.

⁴⁸ “University of Wisconsin: The University Embraces the Following Colleges and Departments.” *The University Press*, Vol. 7, No. 1 (4 January 1876): 1. The University of Wisconsin Archives.

education, but no longer stressed the vital nature of it to either the student's education or future job prospects.⁴⁹

There was a noticeable reason for stressing the practical nature of the University in the mid-1870s. The Board of Regents, following early recommendations by Bascom had raised the price of admission and applied the requirements of application and retention more stringently. As a result, the number of students attending the University dropped precipitously following an all time high attendance of 340 students in 1873. By 1876, the number of students had dropped to 225, though Bascom combined all "collegiate and dependent" courses in his report to the Regents to arrive at a calculated student population of 357. Bascom noted that "secondary changes" had been implemented in the course structure to make them "a little more distinctive" and to allow students in the sciences to extend their practical work. Though the total number of students did increase steadily following these curricular and applied instruction changes, the number of science, engineering, and agricultural students fell to just over seventy total students in 1877. These programs began a slow recovery that lasted well into the 1890s.⁵⁰

Students also got into the act of promoting science instruction and its applications to the public good. Speaking at the 1878 commencement, Harlow S. Eaton, a senior honor student, addressed those in attendance with a short speech on the importance of scientific principles and their applications to the success of business and industry. He complained that the ignorance of businessmen and politicians wasted both money and lives, but argued that

⁴⁹ "The University Embraces the Following Colleges and Departments." *The University Press*, Vol. 13, No. 1 (6 January 1882): 14. The University of Wisconsin Archives.

⁵⁰ John Bascom, "Report of the President." *Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1877* (Madison: David Atwood, Printer and Stereotyper, 1977), 35-39. The University of Wisconsin Archives. See also "Graphic Statistics of the University, 52'-86'." *Trochos*, February, 1887 (Madison: Published by the Junior Class of the University of Wisconsin, 1887): 22-23. The University of Wisconsin Archives.

those trained in the sciences could increase wealth, save time, and increase the general comfort of the nation's population. Eaton also maintained that science provided knowledge, discipline, and "cultivated both memory and judgment," along with teaching close observation, patience, perseverance and sincerity. While his commencement address was admittedly a rosy and idyllic picture of the sciences and applied arts, Eaton's message paralleled the perspective of his instructors and linked the value of science to the changing nature of both his state's and the nation's economy.⁵¹

The diversification in Wisconsin agriculture, manufacturing, and other industrial businesses began relying more on trained individuals by the 1880s. The growth of the state's dairying industry prompted new interest in biological sciences and dramatically improved support for an experimental farm and agricultural science programs at the University. More farmers and businessmen also invested in creameries, necessitating a parallel increase in trained mechanics who could repair and improve the mechanical cream separators and other machinery of the increasingly mechanized farm. The growing pine industry began to rely more heavily on trained surveyors to plot their lands and help design roads that withstood heavy use and rough winter weather. Businessmen also looked for better trained mechanics to run their mechanized sawmills and related machinery. Railroads also needed larger numbers of mechanics and engineers to maintain and repair their steam engines and rolling stock. The economy of scale dictated that on-the-job training no longer fulfilled the needs of business and manufacturing. Technological improvements dictated that the mechanics and engineers needed a high level of training that involved science, mathematics, and practical training.⁵²

⁵¹ Harlow S. Eaton, "Commencement – Scientific Education." *The University Press*, Vol. 9, No. 20 (26 June 1878): 4. The University of Wisconsin Archives.

⁵² William F. Raney, *Wisconsin, A Story of Progress* (New York: Prentice-Hall, Inc., 1940), 280-310.

By the early 1880s, the teaching of technical skills at the University of Wisconsin finally moved beyond ad-hoc shop work time. While faculty and students had access to a small machine shop by 1877, they were limited to one drill and one lathe. In fact, Charles King, the shop superintendent, had only two students in 1878. Administrators began providing some funding that year for a more fully outfitted machine shop, which attracted a growing number of students and created a greater need for space in which to work. By 1882, King reported that he had assisted students in making two metal-working lathes, an iron-boring machine, and numerous wood and metal working tools. He had also procured non-University related work for the shop which provided funds to buy a 12-inch and 30-inch engine lathe for larger woodworking projects. The University had provided only about \$750.00 for tools and supplies in 1882. King and his students built another \$1,050.00 worth of apparatus. Student enrollment increased to thirty-one in the fall of 1881, and had reached forty-students by 1884. King and his students would have to wait until 1886 before a new machine shop was included in the new chemistry laboratory. However, their patience allowed for a new forge, foundry, carpenter shop, and machine shop to be included in the new structure.⁵³

Even though financial constraints continued to plague the University, students and faculty saw steady growth in the engineering departments in the 1880s. While President Bascom threatened to cut the Agricultural department and its practical work for the school and state unless the Board and Legislature increased the appropriate funding, Allan Conover,

⁵³ Charles King, "Practical Mechanics Report." *Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1882* (Madison: David Atwood, State Printer, 1882), 19, 45-48. The University of Wisconsin Archives. On the new machine shop, finished in 1885, see King's description in "The Machine Shop." *Catalogue of the University of Wisconsin for the Academic Year 1885-86* (Madison: David Atwood, Printer and Stereotyper, 1885), 101-102. University of Wisconsin Archives. Some of the specific student enrollment information is mentioned in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 450-451.

Storm Bull, and Charles King quietly went about strengthening the classroom and practical training of civil and mechanical engineers. Though the students chafed at the time and study requirements, engineering studies remained quietly protected from the financial debates of the institution.⁵⁴

Storm Bull, a native of Norway who received his instruction at the Federal Swiss Polytechnic Institute in Zurich and practiced engineering in Europe before coming to the United States, began teaching mechanical engineering at the University of Wisconsin in 1879. He instituted a rigorous program of classroom recitation, shop instruction, and laboratory practice. Students engaged in some form of instruction for thirteen to fourteen hours a day for five days a week.⁵⁵

The civil and mechanical engineering students at the University in the 1880s encountered a dramatically more rigorous program than their predecessors of ten or twenty years earlier had. While the programs were similar to other states, the number of hours students engaged in coursework typically was double or triple that of other land-grant or technical schools. While freshmen had to complete the core humanities and basic mathematics requirements, their next three years focused almost exclusively on science, math, and engineering studies. Sophomores took geometry, chemistry, and calculus. Civil engineering students had courses in surveying, survey drawing, and field practice every term. Mechanical engineering students had courses in machine design and shop practice. Juniors took mechanics, physics, statistics, and material and mineralogy. Both disciplines again had

⁵⁴ Bascom provided a lengthy report on both general and agricultural funding for the University in 1882, though financial concerns crept into most of his reports to the Board of Regents. See John Bascom, "University Colleges." *Annual Report of the Board of Regents of the University of Wisconsin, September 30, 1882* (Madison: David Atwood, State Printer, 1882), 24-30. University of Wisconsin Archives.

⁵⁵ "The Engineering Course." *University Press* (7 February 1885). The University of Wisconsin Archives. Storm Bull's background was mentioned by Curti and Carstensen in *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 451.

specialized field work or shop work. Seniors took advanced hydraulics, metallurgy, motor and machine design, and completed a senior thesis based on their classroom and practical work. Throughout the decade, civil engineering vacillated in emphasis between field-work and drawing, while mechanical engineering increased the amount of the shop-work hours students had to complete.⁵⁶

Conover did create some controversy when he expected additional compensation for overseeing the construction of the new science hall in 1886 through his private engineering office and business firm. The Regents, led by George Paul, stated that professors could not legitimately divide their time between their coursework and paid contract work which involved the University. Apparently it was still okay to do outside work for profit as long as it didn't involve the University or getting paid twice by the school. When Conover noted that humanities professors often got paid for giving lectures to various groups on and off campus, Paul stated that the two cases were incomparable since these lectures reflected the scholarly nature of the University. Clearly, the humanities retained a higher status amongst the members of the Board of Regents, and the sciences and mechanic arts did not yet qualify as "scholarly fields" that represented the University's mission and purpose within the state.⁵⁷

While each member of the faculty focused on their own coursework and projects, Storm Bull, Allan Conover, and Charles King did endeavor to better integrate the departments of mechanical and civil engineering and practical mechanics. Bull provided detailed

⁵⁶ "Department of Civil and Mechanical Engineering." *Catalogue of the University of Wisconsin for the Academic Year 1883-87* (Madison: David Atwood, Printer and Stereotyper, 1883-87), 37-40, 100-104. University of Wisconsin Archives.

⁵⁷ George Paul stated his views and intentions in a letter responding to Elisha Keys, a Board of Regents member, objection to Professor Freeman's lecture series profits. See Paul to Keys, 15-20 April 1885, in the Paul Papers. State Historical Society of Wisconsin. Conover related the story of his contract work, as well as his trip to eastern schools to inspect science and engineering laboratories, in a series of reports to Paul in 1885. See Paul Papers, 22 April and 7 May, 1885. State Historical Society of Wisconsin. This information is also footnoted in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 451-452.

explanations of his coursework along with his aim to make the instruction as practical as possible. In his 1884 report to the Regents, Bull informed them that he consistently required students to spend thirteen hours a week on coursework and ten hours a week on draughting or shop work. That same year, King reported that his students had to spend 965 hours in the shop over four years, but many spent 1,500 to 2,000 hours working on projects. Storm Bull only requested more drawings of machines for his drafting and machine design courses. King was bolder. He noted that the current shop could only accommodate half the enrolled students and their work suffered because of the lack of time and order. His detailed account of space limitation, equipment inadequacies, and limited work time for students resulted in the new machine shop being built as part of the new chemistry and science hall in 1886.⁵⁸

President Bascom recognized the need for faculty to extend their own research as part of the departments they served. In his final report to the Board of Regents in 1887, Bascom implored the Board to support “original faculty work which can alone give constant vigor and growth to its instruction.” For instance, he stated that mathematics offered “intellectual discipline” gave “thought to universal principles” and was a “necessary instrument to any extended study of science.” The sciences “led the mind outward into the physical world.” Bascom aimed to garner support for both the increase of theoretical and practical knowledge which the University could then provide to the various industries and businesses of the state. However, he also warned that continuation of only limited funding, narrowed instruction, and an emphasis on “routine work” would harm the greater mission of the University. The Board,

⁵⁸ Storm Bull, “Department of Mechanical Engineering.” and Charles King, “Department of Practical Mechanics.” *Biennial Report of the Board of Regents of the University of Wisconsin, September 30, 1884* (Madison: Democrat Printing Co., State Printer, 1884), 43-47. University of Wisconsin Archives. Bull, Conover, and King also laid out detailed plans of instruction and practical work in their course descriptions in the 1886 catalogue. Professor John Van Hise also included his connections to civil and mechanical engineering in his course description for “Mining and Metallurgical Engineering.” See *Catalogue of the University of Wisconsin for the Academic Year 1886-87* (Madison: Democrat Printing Co., 1886), 100-104. University of Wisconsin Archives.

administration, and faculty had to improve the pay and resources of the departments to continue to improve instruction and the visibility of the schools' advantage to the state, he insisted.⁵⁹

Bascom's plea for increased funding did finally find favorable support. The Legislature increased the funding for faculty pay, equipment purchase, and provided an annual appropriation to establish new courses in mining and metallurgical engineering, electrical engineering, and railway engineering between 1887 and 1889. While mining and metallurgical engineering coursework had floated between civil and mechanical engineering since 1885, electrical and railway engineering gained support in 1888, with the guidance of the new University president, Thomas Chamberlain, and started formal instruction in the fall of 1889. The University, with the support of politicians looking to improve transportation and communication in the western regions of the state, focused the electrical and railway coursework on practical applications and laboratory research to improve telegraph communications.⁶⁰

President Bascom's limited success came at a high cost. His dedicated work to advance and modernize the University succeeded in some areas. He increased enrollment, hired highly qualified and renowned faculty, and worked diligently to increase the school's appropriations and funding. However, he also invited conflict on numerous fronts. His educational philosophies differed with orthodox religion, the business community, and professional politicians. He had repeatedly, and unsuccessfully, tried to convince the governor that the members of the Board had only their own interests in mind and its

⁵⁹ John Bascom, "University Colleges." *Biennial Report of the Board of Regents of the University of Wisconsin, September 30, 1886* (Madison: Democrat Printing Co., State Printer, 1887), 35-37. University of Wisconsin Archives.

⁶⁰ "New Courses in Electrical and Railway Engineering." *Catalogue of the University of Wisconsin for the Academic Year 1888-89* (Milwaukee: Cramer, Aikens & Cramer, Engravers and Printers, 1889), 123. University of Wisconsin Archives.

membership had to change. His most ardent opponent on the Board, Elisha Keys, who controlled the business affairs of the University, despised Bascom's open support of the Prohibition party and his efforts to oust corrupt politicians. Bascom and the regents also strongly disagreed on the functions and rights each should have. Bascom felt he should have control of faculty appointments, promotion, and firings, student discipline, and, in certain circumstances, the business management of the school. The regents planned to retain overall control of all functions of the university, despite numerous instances of fraud and corruption. Bascom finally relented and offered a drawn out resignation that began in December of 1885 and concluded in June of 1887.⁶¹

Bascom benefited from the new president's inability to take office immediately, thus snubbing the efforts of Elisha Keys to impose a time and terms of dismissal. The Board unanimously elected Thomas Chamberlain to the post in June 1886, but he had to finish his final report to the Wisconsin Geological Survey. In any event, Chamberlain had strong support from the science faculty. Professor Edward Holden, the director of the University observatory, stated in a letter to the Board that "Chamberlain is the man (& so far as I know the only man) who would be entirely acceptable to the Scientific faculty." Chamberlain immediately benefited from the combined support of the faculty and the regents.⁶²

The engineering department finally began to prosper after 1887. Thomas Chamberlain brought to the president's office the mind of a forward looking scientist who understood the

⁶¹ Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 18-19. For a more detailed study of Bascom's tenure as president and his conflicts with the Board of Regents see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 246-295.

⁶² Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 267-270. Holden's comments were in a letter to George Paul. Holden to Paul, 4 May 1885, in the Paul Papers. State Historical Society of Wisconsin. This information is also footnoted in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 268-269.

importance of research, and the practical values that insisted that science serve the people of the state. Chamberlain made a clear distinction between the “study of science” and “scientific study.” The first directed students towards memorization and interest in final results rather than the process by which results were attained. Chamberlain equated the “study of science” with “acquisitive scholarship and ancient erudition.” “Scientific study” on the other hand, equated with “creative scholarship and modern research,” according to Chamberlain. He wanted the character of study, exercising mental actions towards finding results, and the ordering of relationships to matter, rather than simple memorization of subject matter. As president, he focused much of his efforts on restructuring the curricula and instruction in every field to fit this educational philosophy.⁶³

Chamberlain judged principles, policies, and actions by their results, and he demanded that the University train students for the good of the community, not simply the student’s own interest and well-being. He instituted a more aggressive elective system, where students completed general coursework in the first two years, and specialized major and minor studies in the last two years. He insisted that the specialized training for juniors and seniors infuse the techniques of investigation and adequately prepare students for graduate work, regardless of their intended career path.⁶⁴

⁶³ Thomas Chamberlain, “The Ethical Functions of Scientific Study.” *An Address Delivered at the Annual Commencement of the University of Michigan, June 28, 1888* (Ann Arbor: Published by the University, 1888). Chamberlain Papers, Addresses, Essays, Misc Publications, Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives.

⁶⁴ Chamberlain outlined his educational philosophy and his goal of educational organization in his charter-day address given at the University of Nebraska in 1890. See T.C. Chamberlain, “The Coming of Age of State Universities.” *A Charter-Day Address Delivered on the Twenty-First Anniversary of the University of Nebraska, February 15, 1890* (Madison: T.C. Chamberlain, 1890). Chamberlain Addresses, Essays, Misc Publications, Series No. 4/7/1, Box No. 1. University of Wisconsin Archives. On Chamberlain’s educational philosophy, see also Merle Curti and Vernon Carstensen, “The University of Wisconsin: To 1925” in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 23-24.

The engineering department drew special attention regarding practical application from President Chamberlain. While all the colleges and departments acquired much needed funding and underwent significant reorganization, engineering and agriculture studies expanded into new commercially oriented areas. While agriculture benefited from the establishment of the experiment station and applied research programs, Chamberlain also proposed establishing the new departments of electrical and railroad engineering upon entering office. He recognized that the two industries paid significant amounts of money to the state, and Chamberlain aimed to have some of that money funneled into the University programs directly related to those businesses. He concluded that the engineers and managers of electrical and railway businesses would see the training provided by the University as a favor. Rather than increasing the taxes businesses paid, Chamberlain proposed a plan in which portions of their licensing fees would go directly into improving and promoting the technical knowledge and skill the businesses already relied on.⁶⁵

The students saw a dramatic reorganization and specialization of the engineering curricula under Chamberlain's guidance beginning in 1887. Conover, Bull, Hoskins, and King continued on as the engineering faculty and staff, implementing the changes demanded by Chamberlain. The faculty broke the engineering department down into multiple new specializations under the overarching areas of civil, mechanical, mining, and metallurgical engineering. Pure and applied mechanics, overseen by Conover, Bull, and Hoskins, was

⁶⁵ Chamberlain to E.H. Johnson, 22 December 1888. Chamberlain Papers, General Correspondence Files (October 1888-June 1890), Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives. E.H. Johnson appears to be a local businessman connected to either electrical or railroad work. Chamberlain was outlining his efforts, plans, and justification for the two new departments and how they would benefit the industries. He specifically requested Johnson's "approval and co-operation" in "strengthening the movement" and requested any suggestions he might have. On the reorganization of colleges and improvement to various departments see Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 24-25.

made up of elementary mechanics, analytical mechanics, graphic statics for both civil and mechanical engineering, mechanics for materials, theory of structures, mechanics of machinery, and thermodynamics. Topographical engineering, overseen by Hoskins, contained elementary surveying, railroad surveying, topographical surveying, and geodetic surveying. Conover, Bull, and Hoskins also offered special engineering courses in sanitary engineering, hydraulic engineering, machine construction, building construction, mine engineering, steam engines, and hydraulic motors. Students had to take draughting courses in elementary drawing, descriptive geometry problems, elements of machines, graphic statics problems, machine construction, stereotomy, topographical draughting, graphic statics, framed structures, mines and mine timbering, and metallurgical structures. Charles King remained as the superintendent of the shops, overseeing bench work in wood, machine work in wood, pattern work and moulding, hand work in iron, surface plate work with file and scraper, forge work, machine work in iron, tool making, machine construction, and model design, construction, and testing. Freshmen focused on wood work, sophomores on iron work, juniors on tool and machine construction, and seniors on machine design and testing.⁶⁶

The faculty and staff not only had to focus their instructional efforts, they also had to complete the outfitting of the new science hall, begun in 1886 and completed in 1888. The new building contained a new three story chemical laboratory, a new work-shop, and space for zoology, biology, agricultural sciences, mineralogy and geology, physics, and engineering. Every subject area had its own lecture hall, laboratory space, and specialized research room. The engineering department acquired a materials testing machine, cement testing machine, hydraulic flow testing tanks, experimental steam engine apparatus, and numerous other tools

⁶⁶ "Courses." *Catalogue of the University of Wisconsin, 1887-88* (Milwaukee: Cramer, Aikens, & Cramer, Engravers and Printers, 1888), 131-138. University of Wisconsin Archives.

and supplies for experimental testing. The new building was placed close to the campus boiler and power plant so that testing could be done on those systems. Students made an experimental turbine and electrical dynamo for electrical studies, and an engineering museum was created to collect specimens of engineering materials, test specimens, and models of roof and truss bridges, mostly made by students in their courses. The lecture and drawing rooms contained structure and machine drawings, along with models for illustrating geometric and mining principles. The civil engineering rooms contained the transits, levels, water current meters, and surveying chains and tapes.⁶⁷

Chamberlain played a primary role in acquiring the money for this hall and all the new equipment. Following in Bascom's admittedly contentious footsteps, Chamberlain got the state to accept responsibility for financially supporting the institution. By combining finances from the University Fund, Morrill Land Grant Fund, federal government allocations, student fees, and state funding, Chamberlain acquired almost \$227,000 in 1887. Over the next decade, two mill taxes, sale of farm and dairy products from the University farm, fees from railroad licenses, and private gifts raised the total income to \$675,000. By the turn of the regents and state officials boasted that their institution was the most generously supported in the entire region. As part of this increased funding, Chamberlain made sure that the state Legislature appropriated the specific funding for specific parts of the University and specific purposes. The days of general funding for any purpose as dictated by outside businessmen who controlled the Board of Regents were over.⁶⁸

⁶⁷ "The New Science Hall." *Catalogue of the University of Wisconsin, 1887-88* (Milwaukee: Cramer, Aikens, & Cramer, Engravers and Printers, 1888), 161-171. University of Wisconsin Archives.

⁶⁸ Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 20-21. For a more detailed study of the new funding appropriations and how they were spent see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1949), 580-607.

In addition to the new equipment and funding for scientific research, Chamberlain and his supporters on the board worked to promote the practical studies in mechanic arts and engineering as well. In his 1888 report to the governor, board president George Paul requested that a permanent department of mechanical arts be established, as required by the 1862 Morrill Act which by 1888 provided about 30% of the schools funding. Paul noted that a well organized department that focused on the practical skills necessary to the business and industries of the state would provide an “important source of popular support, and largely enhance the practical value of the University.” As the school grew, Chamberlain, Paul, and the rest of the administration and board remained acutely aware of the need for public support for the state university and its support of the state’s various economic and political interests.⁶⁹

Chamberlain focused a great deal of his attention on a department of mechanical arts and a mechanics institute, which could address the broader needs of the working class individuals who didn’t attend college. In February of 1889, he stated to George Paul that “considerable work will be requisite” in order to provide for this kind of specialized and practical instruction. That same month he informed John Angell, the president of the University of Michigan, that he proposed to use one per cent of the licensing fees from the railway and telegraph companies, which amounted to over \$72,000, to establish the railway and electrical engineering courses and develop the department of mechanic arts.⁷⁰

Chamberlain also wrote to state legislators, specifically outlining the funding needs for each program. He proposed that the Mechanics Institute receive a fixed appropriation of

⁶⁹ George Paul, “Annual Report of the Board of Regents.” *Biennial Report of the Board of Regents of the University of Wisconsin, September 30, 1888* (Madison: Democrat Printing Company, State Printers, 1888), 5-8. The University of Wisconsin Archives.

⁷⁰ Chamberlain to George Paul, 8 February 1889. General Correspondence Files (October 1888-June 1890), Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives. Chamberlain to J.B. Angell, 23 February 1889, General Correspondence Files (October 1888-June 1890), Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives.

\$4,000. The department of mechanical arts could then receive the full one percent of the licensing fees from electrical and railway companies, since that department specifically addressed the training needs of future company workers. Chamberlain was skilled enough in his requests to offer multiple proposals, including separating the two projects into distinct subjects for legislative consideration, and deferring to the “eloquence” of individual legislators in their support of the funding appropriation. He even personally invited legislators to tour the campus facilities so that they could offer their own recommendations and see the benefits the engineering and mechanical arts department had to offer. However, Chamberlain maintained his conviction that the programs benefited the state and local economy. He also prodded his supporters along by noting “the time has now come” and “it is necessary to move along some line,” while continuing to ask for their advice and recommendations. While a noted scientist and able administrator, Chamberlain also demonstrated considerable skill in managing and manipulating the support of those he needed in his corner.⁷¹

Chamberlain also went to the people and explained his objectives to them. Addressing the Wisconsin Teacher’s Association in 1891, he explained the origins of the University Extension System in England and how he proposed to implement what he called the “Wisconsin System” for industrial education. His entire plan centered on the idea that all citizens of the state deserved access to specialized instruction, if not higher education. He noted several features of his system that pertained directly to the people. First, the general public called for specialized education and training. Second, the university had a

⁷¹ Chamberlain outlined his funding proposal and the need to act in his letter to Frank Challoner of Oshkosh. Chamberlain to Challoner, 27 February 1889. General Correspondence Files (October 1888-June 1890), Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives. Chamberlain extended his offer for a campus tour five days after soliciting Challoner’s support for funding. Chamberlain to E. Van Coolidge, E.I. Kipp, David Stephens, J.C. Reynolds, and Mark Curtis (individually), 4 March 1889. General Correspondence Files (October 1888-June 1890), Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives.

responsibility to offer the expertise of its faculty and students. Third, modern (meaning extensive, rapid, and cheap) transportation allowed for focused presentations on specialized topics to specialized groups.⁷²

Chamberlain noted that his Wisconsin System focused on the industrial, rather than the cultural as the English system did. It also focused on professional endeavors rather than scholastic pursuits. Chamberlain specifically noted teaching, agriculture, and “industrial artisans,” meaning mechanics and engineers, as the people he wanted to connect with. He wanted the University and its extension services to improve and support the workers of the state, promote the businesses and industries Wisconsin relied on, and as a result, win their encouragement for the increased financial and popular support of the state university. Despite their extensive efforts with legislators and the public, Chamberlain and his staff were still trying to implement a Mechanics institute three years later. The Wisconsin extension service as a whole did not take off until after 1917.⁷³

The engineering departments saw dramatic improvement under Chamberlain’s leadership. The 1890 Morrill Act provided an additional \$15,000 a year, increasing by \$1,000 a year until it reached \$25,000. While most of this money went to the agricultural department, some of the funds did support the expansion of coursework and equipment in engineering. The operating budget of the department increased from under \$2,000 in 1885, to

⁷² T.C. Chamberlain, “University Extension.” *An Address Delivered Before the Wisconsin Teachers’ Association at Madison, December 29, 1890* (Madison: State Journal Printing Company, 1891), 8-9. Chamberlain Addresses, Essays, Misc Publications, Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives.

⁷³ T.C. Chamberlain, “University Extension.” *An Address Delivered Before the Wisconsin Teachers’ Association at Madison, December 29, 1890* (Madison: State Journal Printing Company, 1891), 9-14. Chamberlain Addresses, Essays, Misc Publications, Series No. 4/7/1, Box No. 1. The University of Wisconsin Archives. On the University Extension Service, see W. H. Glover, *Farm and College: The College of Agriculture of the University of Wisconsin, A History* (Madison: The University of Wisconsin Press, 1952), 202-227; and John Buenker, *The History of Wisconsin, Volume IV, The Progressive Era, 1893-1914* (Madison: State Historical Society of Wisconsin, 1998), 376-388.

almost \$5,000 in 1890. Faculty salaries ranged from \$400 for instructors, to \$1,000 to \$2,000 for full professors. The board even recommended that at least one professor be allowed to tour “advanced institutions of instruction” so that engineering and mechanical arts could keep up with “improvements and new methods.”⁷⁴

Most importantly, the engineering faculty increased from a staff of four to over ten members between 1888 and 1890. Joining Conover, Bull, Hoskins, and King were Charles Marx in civil engineering, Dugald Jackson in electrical engineering, Albert Smith and then Forrest Jones in machine design, Nelson Whitney in railway engineering, Charles Wing and then Frederick Turneure in bridge and hydraulic engineering, and Edward Mauer and Arthur Richter as instructors in engineering. The new faculty members had all earned advanced degrees in civil or mechanical engineering, highlighting Chamberlain’s focus hiring on professional faculty with advanced training in their specialized fields.⁷⁵

By 1892, the faculty and administration had fully organized the college of engineering. Eight faculty members each specialized in a distinct engineering area, including steam, electrical, machine design, railway, mechanic practice, theoretical and applied mechanics, and bridge and hydraulic engineering. Sixteen other professors filled out the faculty of the college of mechanics and engineering, covering mathematics, sciences, and the languages. Students followed one of four discipline systems; mechanical engineering, electrical engineering, and either railway or structural engineering in the civil engineering field. Students took mathematics coursework in algebra, geometry, trigonometry, statistics,

⁷⁴ For salaries and department budgets, see “Disbursements, 1890,” on the increasing budget of the Engineering Department see T.C. Chamberlain, “President’s Report,” and on the faculty hiring between 1888 and 1890 see George W. Bird, “Report of the Board of Visitors.” *Fourth Biennial Report of the Board of Regents of the University of Wisconsin, 1888-89, 1889-90* (Madison: Democrat Printing Co, 1890), 25-27, 46-47, and 54. University of Wisconsin Archives.

⁷⁵ T.C. Chamberlain, “President’s Report.” *Fourth Biennial Report of the Board of Regents of the University of Wisconsin, 1888-89, 1889-90* (Madison: Democrat Printing Co, 1890), 46-47. University of Wisconsin Archives.

and calculus. Sciences included chemistry, physics, astronomy, and geology. Freshmen took French or German, along with English and rhetoric. Sophomores, juniors and seniors took specialized coursework in their fields, such as structural engineering, railway engineering, pure and applied mechanics, electrical engineering, machine design, and hydraulic engineering. Every student took 140 hours of shop work in a specialized course for wood, iron, tool and machine design, or model construction and testing. Each student also had an additional 140 to 180 hours of laboratory work in a specialized engineering field; surveying, structural, railway, machine design, or laboratory work in hydraulics, electricity, or drafting. While specialized prevailed in the students' education, Chamberlain and his staff also promoted the practical training each student received. They wanted the University to serve the public through well trained graduates, as well as increasing knowledge through laboratory research.⁷⁶

The state's economy also began to benefit from having more highly trained and skilled workers by the late 1880s and early 1890s. The consolidation of the railroads, which had begun in the 1860s and continued for the next thirty years, attracted many new investors to follow the economic growth involved in railroad expansion westward and northward. The railroad and lumber companies and mine operators needed mechanics to design new and improved equipment. Surveyors and geologists were needed to plan roads, plot land holdings, and investigate the newly discovered mineral deposits in the northern regions of the state. Agricultural machinery producers needed mechanical designers, engineers, and skilled shop workers for their growing factories. Other industries, such as tanning, meat-packing, papermaking, and even breweries began to rely more heavily on the scientific training that the

⁷⁶ "College of Mechanics and Engineering." *Catalogue of the University of Wisconsin, 1891-1892* (Madison: State Journal Printing Co., 1892), 136-166. University of Wisconsin Archives.

University had to offer, both in the classroom and in the extension classes that the University began offering throughout the state. The administrators and faculty at the university took the opportunity to improve both their financial situation, through the licensure fees imposed on railways and electrical companies, and the course offerings. As administrators and faculty reorganized and diversified the engineering program, they gained wider support from those in the railroad fields and agricultural and industrial manufacturing. By offering significantly more specialized and expanded coursework in fields directly related to the technical fields of state businesses, such as machine design, hydraulics, and electrical and mining engineering, as well as offering extension classes, the University faculty and graduates made their programs important to the modernization and growth of the state.⁷⁷

Thomas Chamberlain led the reorganization of the college of engineering into specialized fields that promoted the University to the state. Charles Kendall Adams expanded the University's reach to a national level. However, Chamberlain left Wisconsin in 1892 to head the geology department at the University of Chicago. Then, Adams gained widespread acclaim for restoring interest in the classics and humanities, while also improving faculty salaries, retaining noted scholars, and raising academic standards for students. He wanted the University of Wisconsin to attain national prominence in both the sciences and humanities, while also continuing to serve the state's business, industrial, and educational needs.⁷⁸

Born in Vermont, raised in Iowa, educated and employed at the University of Michigan, and experienced as an administrator at Cornell University, Adams embodied a unique educational philosophy. He had the experiences of the Midwest combined with the

⁷⁷ Robert C. Nesbit, *Wisconsin, A History* (Madison: The University of Wisconsin Press, 1973), 331-335.

⁷⁸ Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 25-27. For a more detailed study of Adams' presidency see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 561-579.

classical attitudes and intellectual leanings of the East. He mixed frontier common sense with eastern modernity and professionalism. Adams worked diligently throughout his careers to more closely connect the instruction of humanities and sciences so that citizens could be more enlightened in their opinions, conduct, and governance of society. He believed that every citizen should be an educated scholar, and education embraced knowledge and practical experience alike. In his inaugural address, Adams noted that a close relationship existed between progress and power, and they both relied on education. In order for the University of Wisconsin to fulfill what Adams saw as its primary responsibility, the institution would have to increase funding, construct new and modern buildings, provide a better library, and increase the faculty and staff of every department.⁷⁹

While Chamberlain had laid the groundwork and guided the institution from a frontier college into a modern university, Adams gained the credit for it. The editor of the *Wisconsin State Journal* noted that citizens could “indulge in a new era of prosperity.” The editor of the *Madison Democrat* stated that “all felt the institution was in the dawn of a new and expansive era.” Chamberlain and his staff organized and implemented new programs and curricula, especially in the fields of mechanics and engineering. Adams finished filling out the new departments, reconciled the conflicting demands of competing subject areas, and secured the

⁷⁹ Adams’ background can be found in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 563-567. Adams organized his thoughts on national prosperity and education in an 1876 address at the University of Vermont while he was a professor of history at the University of Michigan. See Charles Kendall Adams, “The Relations of Higher Education to National Prosperity.” *An Oration Delivered Before the Phi Beta Kappa Society of the University of Vermont, June 27, 1876* (Burlington: Free Press Print, 1876), 3-27. Adams Papers, Addresses, Essays, Etc. Series No. 4/8/1/1 M3I2. Box No. 1. The University of Wisconsin Archives. See also, Charles Kendall Adams, “The University and the State.” *The Addresses at the Inauguration of Charles Kendall Adams, January 17, 1893* (Madison: Published by the University, 1893), 45-69. Adams Papers. Address, Essays, Etc. Series No. 4/8/1/1 M 3I2. Box No. 1. The University of Wisconsin Archives.

increased funding needed to expand and successfully implement Chamberlain's educational programs.⁸⁰

By the early 1890s, scholars and administrators across the nation began to view the University of Wisconsin as one of the premier institutions of higher learning. Predominantly through the work of Bascom, Chamberlain, and Adams, all areas of the institution gained academic credibility, while also managing to serve the state's agricultural, scientific, and manufacturing needs. While other land-grant schools labored on as technical or agriculturally focused institutions, faculty and students at the University of Wisconsin benefited from a combination of science and humanities, effectively feeding the growing intellectual class that comprised the progressive movement in the state and Midwest region. Chamberlain's effective use of state, private, and licensure funding to improve and direct the college of engineering quickly transformed the mechanics and engineering curricula from a struggling craft and service program into a professional engineering program that compared favorably to eastern engineering colleges and departments.⁸¹

By the late 1880s and through the 1890s, administrators provided funding and time for faculty to do research that furthered their professional careers, while also benefiting the state's

⁸⁰ "Editorial." *Wisconsin State Journal*, 17 January 1893, and "Editorial." *Madison Democrat*, 19 January 1893. Both quotes are found in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848-1925*, Vol. 1 (Madison, University of Wisconsin Press, 1849), 569, ff 26-27.

⁸¹ On the national character of the University of Wisconsin by 1890 and the school's connections to the rise of the Progressive Movement, see Merle Curti and Vernon Carstensen, "The University of Wisconsin: To 1925" in *The University of Wisconsin, One Hundred and Twenty-Five Years*, ed. Allan Bogue and Robert Taylor (Madison: the University of Wisconsin Press, 1975), 25-27. Many scholars have also tied the rise of the Wisconsin Idea to the origins of the Progressive Movement, New Education, and the "systematizing" of American life that began in the 1870s. For an analysis of "systematizing" in America see Alan I Marcus and Howard P. Segal, *Technology in America: A Brief History*, 2nd Edition (New York, 1999), 143-205; and Joel Colton and Stuart Bruchey, "Introduction," and Harold G. Vatter, "Technological Innovation and Social Change in the United States, 1870-1980," in Joel Colton and Stuart Bruchey, eds., *Technology, the Economy, and Society: The American Experience* (New York, 1987), 1-37. On the connections between the Wisconsin System and New Education, see John Buenker, *The History of Wisconsin, Volume IV, The Progressive Era, 1893-1914* (Madison: State Historical Society of Wisconsin, 1998), 303-386. For the connections between the Progressive Era, New Education, and industry see Lawrence Cremin, *The Transformation of the School, Progressivism in American Education, 1876-1957* (New York: Random House, 1961), 23-58.

economy with well-trained graduates who had applied engineering skills. Administrators and faculty continued to develop the engineering programs in this fashion for the rest of the decade and into the twentieth century. Additionally, the increased prominence of professional societies and the demands of the engineering profession itself began to play a more significant role in the development of engineering curricula and programs at the University.

CHAPTER 5.

SCIENCE WITH PRACTICE – THE IOWA AGRICULTURAL COLLEGE BEFORE 1893¹

From its beginnings, Iowans wanted Easterners, and more importantly potential settlers, to view the state as modern and progressive. By the mid-nineteenth century, this meant a technically advanced, scientifically supported cultural framework. People who came to Iowa wanted modern improvements in infrastructure, a political system that promoted business and practical education, and opportunities for social and economic advancement.

As a land-grant school, the early history of the Iowa Agricultural and Mechanic Arts College is directly related to the emergence of Iowa statehood. In December of 1841, John Chambers, the territorial governor, sent his first message to the Iowa Legislative Assembly. He noted that the population of the territory had risen dramatically and that the territory of Iowa, if it moved toward statehood, would be in a favorable position to take advantage of the “Distribution Act” which Congress had just passed. Chambers knew that two important parts of this act would benefit the Iowa territory as a new state. First, as a state, Iowa would have access to the pro rata distribution of the net proceeds of the sales of public lands. State and local government officials could then use this money to establish city, county, and state agencies to promote the settlement of the state. Second, every new state that was admitted to the Union would be granted five hundred thousand acres of land, the proceeds going specifically to fund internal improvements. Chambers knew that the original objections to state organization raised by citizens, particularly businessmen, centered on the concern that heavy taxes would stunt economic growth. The provisions of the Distribution Act dispelled

¹ The official Iowa State University motto originated with the first president of the Agricultural College, Adonijah Welch.

these objections and highlighted the technical necessities needed to open up the upper Midwest to settlers and industry.²

In 1846, Iowa became a state. Though boundary disputes hampered the acceptance of a state constitution by the federal government, legislators finally compromised and submitted an acceptable document in 1846. The majority of the constitution dealt with the typical government establishments, powers, and responsibilities. But of special interest to those involved in the “practical and useful arts” was Article X on “Education and School Lands”. The General Assembly had to organize school elections and “encourage, by all suitable means, the promotion of intellectual, scientific, moral and agricultural improvement.”³

Technical knowledge played an important role in establishing Iowa as a modern and progressive addition to the western frontier. While subsistence farming dominated Iowa economics, business and industry in the nineteenth century, farmers were not alone in their endeavor to tame the prairie lands. Mechanically adept individuals had to accompany them into the region to supply the tools, machines, and transportation systems needed for agriculture to flourish.

Iowa settlers engaged in numerous business and industrial ventures before 1860. Steamboats brought many of the first settlers to the region in the 1830s and continued to bring in large quantities of supplies and people while carrying away significant portions of the

² Benjamin Shambaugh, *The Constitutions of Iowa* (Iowa City: The State Historical Society of Iowa, 1934), 105-106, 108-117. Shambaugh provides significant detail regarding the initial attempts to create a state constitution and why the debates lasted so long. The primary roadblocks for the first state constitution resided in boundary disputes, banking and business provisions the severely regulated lending and investment opportunities, and taxation policies proposed to support the state and local governments while building up the physical infrastructure.

³ Benjamin Shambaugh, *The Constitutions of Iowa* (Iowa City: The State Historical Society of Iowa, 1934), 194-197. The 1846 constitution contained the typical articles present in most state constitutions of the day; a preamble, bill of rights, right of suffrage, separation of powers, establishment of legislative, executive, and judicial branches of government, provisions for a state militia, limits on public debt and liabilities, restrictions on banking and business corporations, systems of county and township governments, provisions for amendments to the constitution, and a schedule for transition from territorial to state organization.

annual harvest until the late 1860s. By the 1850s, railroads had begun to creep across the eastern portions of the state, reaching Des Moines by 1860 and the Missouri River by 1867. Every town had a sawmill and a gristmill, while larger cities along the Mississippi had slaughter houses, carriage manufacturers, and breweries. Dubuque prospered in the 1850s due to the proximity of a lead mine and the establishment of the Dubuque Boat and Boiler Company, which manufactured steamboats. In order to prosper and develop, owners had to bring in technically skilled workers and managers. However, these business and manufacturing ventures relied primarily on the agricultural basis of the state. So the success of agriculture remained foremost in the social and political development of the Iowa region, eventually prompting calls for higher education to support the agricultural and industrial classes.⁴

By the latter half of the 1850s, three important factors played a role in the establishment of a new agricultural college; a new state constitution, the failure of the University of Iowa by 1858, and the combined push for an agricultural college by Benjamin Gue, a state legislator, and supporters of state agriculture. At the 1857 state convention, legislators moved to revisit all the articles of the 1846 constitution starting with questions about the regulations on banking and corporations. During this convention, legislators proceeded to examine the initial failures and shortcomings of the University of Iowa, ultimately leading to the short-term closure of the University and the establishment of a Board of Education. Meanwhile, Benjamin Gue and other sympathetic legislators continued pushing

⁴ In the 1850s, steamboats could navigate 250 miles of the Des Moines River and 110 miles of the Iowa River. See Hunt's *Merchant Magazine*, Vol. 31 (1854): 76. Dorothy Schwieder briefly covers the basic economic background of Iowa between 1830 and 1860, including the use of steamboats, the development of local economic enterprises, and railroads. See Dorothy Schwieder, *Iowa, The Middle Land* (Ames: Iowa State University Press, 1996), 57-65. The lumber industry also played an important role in the expansion of eastern and central Iowa towns. Settlers required better quality wood than could be found in the local region, so much of it was floated down river from Minnesota and Wisconsin and then processed in local sawmills. See Leland L. Sage, *A History of Iowa* (Ames: The Iowa State University Press, 1974), 97-99.

for specialized agricultural instruction. Vocal agricultural groups were also agitating for a practical education for farmers. These interests coalesced in 1858 to allow for the founding of an agricultural college based on European and east coast models.

In 1857, the state legislature called for a new constitution which contained several amendments covering the entire 1846 Constitution.⁵ Paying particular interest to the technical improvements of the state, the legislators recognized severe limitations in the existing public education system of Iowa. They created a Board of Education, with qualifications for election, times and places of meetings, elected officers, duties and power of the Board, and compensation for members. The General Assembly also gained control of all educational and school funds and lands. This meant that all educational activities within Iowa had to go through the state legislature, and that Iowa legislators would review all activities conducted by state educational institutions.⁶

While state legislators debated the intricacies of the new constitution and possible amendments prior to 1857, the education system struggled to provide for the widespread population and rapidly changing needs of the state. Privately funded, one room log cabin schools opened as early settlers entered the state in the 1830s. Teachers offered rudimentary instruction in reading, writing and arithmetic, while parents guided youngsters through

⁵ Benjamin Shambaugh, *The Constitutions of Iowa* (Iowa City: The State Historical Society of Iowa, 1934), 269-280. The 1857 convention dealt with almost every section of the state constitution; additions to the "Bill of Rights", details of voter residence, legislative action matters, terms of office, a complete rewriting of the article concerning the Judicial Department, more explicit and guarded phrasing on state debts, fewer restriction on corporations and banks, creation of a Board of Education and the overall control of the General Assembly in the educational system, greater flexibility in the process of amending the state constitution, and final recommendations and decisions on relocating the state capital to Des Moines and allowing the University of Iowa to remain in Iowa City. The General Assembly was granted power, after 1863, "to abolish or reorganize said Board of Education, and provide for the educational interest of the State in any other manner that to them shall seem best and proper." Under this provision, the General Assembly eventually abolished the Board of Education in 1864, but the sections were not repealed. The primary result of getting rid of the Board was that after 1864, reports from state educational institutions became biennial rather than annual and were addressed to the Board of Trustees rather than the Board of Education.

⁶ Benjamin Shambaugh, *The Constitutions of Iowa* (Iowa City: The State Historical Society of Iowa, 1934), 277-278.

various farm chores and practical instruction as it related to immediate farm concerns. In 1840, the territorial legislature adopted section for section the Michigan school law of 1838, which eventually dictated the structure of the educational system included in the 1846 Constitution. Secondary education gained authorization in 1849 and D. Franklin Wells, a product of Iowa public schools, began promoting the public high school movement in 1856, arguing for the economic, educational, and social advantages of public high schools in a democracy. Communities slowly saw the establishment of public high schools between the latter 1850s and the late 1870s.⁷

The issue of Iowa education beyond high school, however, remained unresolved. Pioneer settlers brought the European Academy idea with them as they traveled west during the early decades of settlement in the territory west of the Mississippi, peaking in the 1850s and 1860s. This concept represented a combination of modern high schools and small colleges, with instructors focused on languages (typically Greek and Latin) history, philosophy, and limited mathematics. But these institutions suffered from two great weaknesses. First, only children of well-off families could afford to attend, since these institutions depended on tuition payments. Second, pioneer families required and increasingly asked for more practical education. Iowa academies increasingly emphasized modern languages, natural science, surveying, and bookkeeping. While eastern colleges continued to rely on a classically based system of admission and instruction, Iowa colleges set entrance requirements to conform to the more practical academy and public school systems of instruction.⁸

⁷ William J. Peterson, *The Story of Iowa, The Progress of an American State*, Vol. 2 (New York: Lewis Historical Publishing Co., 1952), 845-851, 860-864.

⁸ William J. Peterson, *The Story of Iowa, The Progress of an American State*, Vol. 2 (New York: Lewis Historical Publishing Co., 1952), 854-855.

While private, denominational colleges based on East coast elite models sprouted up across the state in between the 1840s and 1860s, several colleges opened in the late 1830s and 1840s which attempted to address technical instruction. Local officials established the Davenport Manual Labor College in January 1838, though it soon failed due to a lack of funds and a lack of students. In Iowa City, The Mechanics' Mutual Aid Association established the Mechanics' Academy in 1842 with an enrollment of one hundred and twenty. It failed within just a couple of years, but the building became the first structure for the University of Iowa. These early denominational colleges and technical institutions, such as Iowa City's failed Mechanics Academy followed eastern models of instruction based on traditional methods rather than practical experiences relevant to the necessities of the frontier.⁹

At the state level, Iowa leaders began asking for a school of a technical nature as early as 1854. Governor James W. Grimes proposed that the state redistribute the funds set aside for the University of Iowa, organized in 1847 but not opened until 1855, and establish a polytechnic school. Governor Grimes cited the state's need for more educated farmers, mechanics, engineers, architects, chemists, metallurgists, and geologists, rather than more doctors and lawyers. He specifically noted that the state's economy would benefit greatly if farmers became more familiar with the principles of chemistry as they applied to agriculture.¹⁰

Officials at the University of Iowa attempted to integrate modern sciences into the organization and curriculum of the school before it opened in 1855. However, the school's

⁹ William J. Peterson, *The Story of Iowa, The Progress of an American State*, Vol. 2 (New York: Lewis Historical Publishing Co., 1952), 855-858, 869-902. Denominational and private colleges set their own curricula and programs of study, but relied on eastern models for guidance. College leaders focused on classical programs of study and most of these institutions focused on training denominational clergy.

¹⁰ Benjamin Shambaugh, *Messages and Proclamations of the Governors of Iowa*, Vol. II: 8, 9. Cited in Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 173-174 ff.

mission to promote classical higher learning soon clashed with the zeal which accompanied the push for modern science and progress afforded by the “useful arts.” The University tried to maintain a balancing act that resulted in a significant number of science courses that coexisted alongside a classically oriented curriculum. In the University’s initial organization, faculty members were supposed to cover geology, natural history, zoology, mineralogy, meteorology, and chemistry. Another department, known simply as “department VIII”, was intended to cover the principles of hydrostatics, pneumatics, optics, acoustics, astronomy, mechanics, and mechanical philosophy. Department IX included analytical, elementary, inorganic and organic chemistry. Professors in these departments were given the option of including “applications to agriculture and the arts.” Though definitely scientifically oriented, this curriculum provided little or no “applied” instruction. In fact, beyond the possible application of chemistry, faculty members were under no pressure from the University’s leadership to include “useful arts” or practical applications in their classroom instruction. Agriculture was simply not a focus of interest.¹¹

Though they promised a modern and practical education, University leaders did not fulfill Iowans original expectations. Due to absent leadership, low enrollment, and limited teaching experience, most of the science courses did not appear immediately; professors only offered courses in modern and ancient languages, mathematics, and natural philosophy. University leaders assured the public that additional coursework would be added “as fast as the people of Iowa will furnish students to be instructed.” The combination of low enrollment and unfulfilled promises caused the University to close between 1858 and 1860. State leaders reorganized and reopened the school in 1860, but enrollment remained low until after 1864

¹¹ Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 171-176.

due to the Civil War and substandard public education at the secondary levels. With the systematic failure of the state supported university and the unfulfilled but constitutionally supported ideals of scientific and practical instruction, the way was open for a new educational program.¹²

The origins of the Iowa Agricultural College reside in efforts of two groups, the State Agricultural Society, and a group of young legislators who refused to recognize defeat. On December 28, 1853, southeastern farmers and businessmen in Fairfield organized the State Agricultural Society of Iowa. They immediately presented claims for state aid to the General Assembly, including a provision which stated, "The crowning merit of the age was the conspicuous movement to elevate the standard of agriculture through the aid of the natural sciences, and it had become the duty of the State to act in harmony with this movement." Society members called for Iowa to establish a bureau staffed by geologists and agricultural chemists who could experiment, observe, and recommend the most beneficial agricultural practices for the various regions of the state.¹³

The General Assembly of Iowa had asked Congress to donate land and buildings at the Fort Atkinson site in 1848, for the express purpose of establishing an agricultural school. They intended for this school to eventually become a branch of the University of Iowa.¹⁴

¹² Stow Persons, *The University of Iowa in the Twentieth Century, An Institutional History* (Iowa City: University of Iowa Press, 1990), 2-10. Person's provides a brief synopsis of the University's background before 1900 in his prologue. He notes that the original University of Iowa failed mainly due to poor leadership. Chancellor Amos Dean, who was also professor of history, visited the campus at it's opening, but immediately returned to Albany, New York, and never returned. While leadership remained non-existent, the curricular plan also failed to meet expectations. Organizers planned for nine departments, covering a comprehensive program of study in ancient languages, modern languages, mathematics, intellectual philosophy, moral philosophy, natural history, natural philosophy, and chemistry. However, a faculty of only four professors managed just four classes; ancient and modern languages, mathematics, and natural philosophy.

¹³ Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 193-194.

¹⁴ Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 197ff. The provisional act locating an agricultural branch of the University at Fort Atkinson does not

Early supporters, joined by members of the Agricultural Society, continued to agitate for state supported agricultural instruction. The noted that “Agriculture being the leading interest in this state, we desire to elevate the condition of those who engage in it, to cause it to be regarded as a progressive science; and for this purpose to furnish our young men with the means of combining sound theory with useful observation and experiment.”¹⁵

Society members circulated numerous petitions for an agricultural college during the 1858 General Assembly. Members of Franklin Township, within the present day boundaries of Ames, in Story County volunteered to assist in any donation of land or equipment needed to secure the location of an agricultural college in their community. They highlighted the benefits of a central location, high quality farm ground, and close access to two major rail lines. Meanwhile, Agricultural Society members continued to petition the state legislators, hopeful that achievements in applied sciences in other regions of the country would result in an Iowa agricultural college that focused on teaching natural sciences and associated practical applications.¹⁶

Several young legislators assured the success of the agricultural college act for Iowa. Benjamin Gue, Robert Richardson, and Ed Wright had arrived in Iowa in 1852 and quickly became active in local politics, working for reforms ranging from abolitionism and religious freedom to educational opportunities and industrial development. Conscious of his own educational shortcomings, Benjamin Gue adamantly questioned why “land grants and money endowment be given to enable the wealthy who choose the so-called learned professions to

appear in the House or Senate statutes. During an extra session of 1848, legislators in the House passed an act locating branches of the University, but it was indefinitely postponed in the Senate.

¹⁵ Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 196. The passage is designated as a quote by Aurner, but no citation or reference is given as to where it originated.

¹⁶ Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 197-198. Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 12-13.

get all the inestimable benefits of a university education while the sons and daughters of the mechanics, farmers and all grades of workers were deprived.”¹⁷

The three new legislators proposed a bill to fund an agricultural college in early 1858. They revised a previous bill, which had failed horribly a year earlier, and Richardson presented the documents “for the establishment of a State Agricultural College and Farm with a Board of Trustees.” Gue promoted and defended the bill by saying that lack of educational opportunity caused ambitious country boys to seek other occupations, with the result that rural leadership was quickly draining away from Iowa. Advocates proposed that a new college should “train leaders in business and public affairs as well as expert technicians.” Gue concluded his statements to the General Assembly by stressing that the “working, producing classes,” which included farmers and “all the laboring classes, mechanics, day laborers, inventors, and manufacturers,” were ready for an institution of higher learning which addressed their needs.¹⁸

Gue and his fellow legislators, distrustful of administrative meddling and certain of their own ability to organize the new school, laid out a plan that became one of the standard agricultural and industrial college models.¹⁹ They listed a program of study that included all manner of agriculturally connected subjects from natural philosophy, chemistry, and botany, to animal and plant anatomy and meteorology. They also included leveling, surveying,

¹⁷ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 16-17.

¹⁸ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 19-20.

¹⁹ Gue and the other board members did not organize and construct the college from scratch. Between 1857 and 1860 they corresponded with the agricultural colleges of Michigan and New York, by 1858 the only two operating agricultural colleges in the United States. The Board also visited the Farmers’ High School of Pennsylvania and the Farmers’ College and Female College near Cincinnati. Most of their observations centered on plans for a main building and how to best locate other structures such as a farmhouse, barns, and minor equipment buildings. See Clarence Aurner, *History of Education in Iowa*, Vol. IV (Iowa City: The State Historical Society of Iowa, 1916), 202-203.

bookkeeping, and “such mechanic arts as are directly connected with Agriculture.” While agriculture remained paramount, administrators had the foresight to include industrial and useful arts that ranged well beyond the farm and benefited other businesses as well as the state growing infrastructure.²⁰

While supporters of the agricultural college worked to advance this proposal, economic pressures of the latter 1850s slowed its progress. A national depression destroyed public and private credit, devastated all but the strongest businesses, and reduced the standard of living to subsistence levels. Record rainfalls in 1858 and 1859 resulted in crop shortages, pushing farmers and businessmen alike back to the east coast and into more populated regions like Chicago, Detroit and St. Louis. Opponents of the proposed college repeatedly cited the danger of high taxes, unwanted by the majority of citizens. With the state only half settled in 1860, they warned that creating a new college would increase the financial distress of the state and local governments. Proponents countered with reports that if the facts and potential benefits of a practical education in the west could be “put into the hands of the industrial classes of the Eastern States” it would stimulate immigration to the “cheap and fertile lands of Iowa.” These reports floundered in the back pages of newspapers and pamphlets and never made it beyond local discussions. Finally, the outbreak of the Civil War in 1861 severely depleted the number of available students and shifted the legislative focus to national and military concerns.²¹

Despite the ongoing crises of the late 1850s, Iowa legislators authorized the establishment of the agricultural college; fully expecting to receive some form of federal aid.

²⁰ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 21-22.

²¹ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 14-15, 31-34.

In 1858, they had asked for a donation of 50,000 acres of public land from Congress, but national sectional squabbling prevented the first Morrill land grant bill from passage. On July 2, 1862, with southern opposition removed, the Morrill Bill passed through Congress and on September 3, 1862, the Iowa General Assembly officially became the first state to accept the grant.²²

Early attempts by University administrators and legislators from eastern counties to split the funding between the Agricultural College in Ames and the University in Iowa City failed largely due to the growing presence of farmers and manufacturing enterprises in the central portions of the state. However, the supporters of the Agricultural College had to wait another six years before the institution actually opened its doors. Between 1862 and 1867, trustees of the farm land in Story County leased it out while committees in Des Moines worked on building plans, funding, and administrative organization. The organizing committee included the Governor, now Lieutenant Governor Benjamin Gue, and Peter Melendy, the president of the State Agricultural Society. These men emphasized the importance of agricultural development to Iowa's economic development and growing importance of practical education in an increasingly industrialized society. In order to obtain a broad survey of curricula, facility planning, and administrative organization, they traveled to twelve states and visited sixteen colleges and schools, the Smithsonian Institution in Washington D.C., and numerous federal agricultural and educational offices. The lengthy process of developing the college lands, combined with the extensive travels and deliberations

²² Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 35-40. Iowa's status as the first state to accept the provisions of the 1862 Morrill Act appears to stem from the timely coincidence that the Iowa General Assembly was meeting to discuss war concerns in September, just two months after the Morrill Act passed. Other agricultural colleges, especially Michigan State University, also claim the title of "first" based on the status of the colleges and acceptance of the Morrill Grant Funds prior to the passage of the 1862 Morrill Act. See Madison Kuhn, *Michigan State, The First Hundred Years, 1855-1955* (East Lansing: The Michigan State University Press, 1955), 71.

of the committee, led to the extended delays between founding the college, accepting the Morrill Act funds, and actually opening the college to students.²³

In early 1868, the Iowa State Board of Trustees accepted the college organizing committee's recommendation to hire Adonijah Welch, organizer of Michigan's normal school and Florida Senator, as the first college president. It would be Welch's responsibility to address the concerns of citizens and implement a course of instruction beneficial to the young men and women of Iowa. The college organizing committee had picked Welch on the basis of recommendations from the college presidents of Michigan, Kansas, and Antioch Colleges, along with numerous others who emphasized Welch's "special qualifications and adaptability."²⁴

President Welch entered a tempestuous Iowa environment, endeavoring to mediate between two groups who sought to control the design and course of the college. One group consisted of educators and businessmen who supported a broad-based, liberal form of education. They believed education required a wide range of studies, including theoretical sciences, business courses, and modern languages, as well as rhetoric, Latin, and philosophy. This liberal style of education also included practical skill training in the laboratory and shop, so that students could apply the principles learned in the classroom to the real world. The other group vying for control of the college consisted primarily of persons directly involved in agriculture and manufacturing. These farmers and laborers desired a practical and applied course of agriculture and mechanic arts instruction. These proponents called for less

²³ Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 51-58. Ross provides details on the committee's members, travels, deliberations, and specifics on their recommendations as pertained to the discourse between the state legislature, the organizing committee, and the state Board of Education.

²⁴ Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942): 59. Welch had acted as principal of the state normal school at Ypsilanti, Michigan from 1852 to 1865. He then moved to Florida and represented the state in the Senate from 1868 to 1869.

classroom study and more time spent in the shop and field acquiring skills necessary for farming and industrial work.²⁵

Though the college had been chartered in 1858, Iowa legislators did not allocate state funds for the college until the state accepted the federal land-grant allocation. Since organizers had done little in the way of organization beyond the initial charter and even less in terms of building the infrastructure of the college grounds, the agricultural college's first appointed leaders had a clean slate on which to construct the curriculum and develop the facilities. Welch and his original staff relied on the broader wording of the 1862 Morrill Act as justification for including both agriculture and mechanic arts in their original programs of study. In effect, Welch and other faculty members could apply several different educational styles, including classroom study that relied on theoretical understanding and practical instruction that utilized shop and field experiences.²⁶

Adonijah Welch set the tone for the fifteen years of instruction. A graduate of the University of Michigan, and avowed supporter scientific and practical education, Welch organized the college based on language of the Morrill Act; "to teach such branches of learning as are related to agriculture and the mechanic arts,...and to educate the industrial classes for the pursuits in life." Welch recognized that the spirit of the law forbid the subordination of any one educational style or program of study over another, as largely occurred in Michigan. He wanted liberal arts instruction mixed with practical education and mechanic arts placed on an equal footing with agricultural. Furthermore, Welch realized that to succeed, this new college must "answer the wants of modern life" by making modern

²⁵ Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942): 116-17. Joseph Bailey, *Seaman A. Knapp: School Master of American Agriculture* (New York: Columbia University Press, 1945): 80-81.

²⁶ For an analysis of Iowa Agriculture College's early years see Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942).

applied sciences the primary focus and uniting labor and study to attain “health, practical knowledge and manual skill.”²⁷ Welch wanted to make sure that both agricultural and industrial knowledge flourished alongside one another.

Welch managed to placate both the classical and practical groups successfully, organizing the curriculum so as to include adequate amounts of theoretical classroom study and moderate amounts of laboratory and shop instruction, supplemented by a prescribed number of manual labor hours each week. In his opening address, delivered in 1869, Welch highlighted how the educational approach he planned on implementing required a foundation of scientific principles. With this foundation, and a strong work ethic promoted through labor and study, young men and women could develop moral and mental discipline so vitally important for their perceived well-being.²⁸

Like Welch, many land-grant school organizers attempted to implement manual labor into their own particular system of education. Most administrations quickly surmised that the inclusion of mandatory work degraded the college experience. Many felt the requirement kept students away from their studies.²⁹ Welch persisted in his belief that manual labor provided an integral part of each student’s overall educational experience. He, along with the college trustees, repeatedly stressed that honorable men and women performed honorable labor. They considered labor an “essential part of the student’s education, and necessary for

²⁷ Adonijah Welch, *Plan of Organization of the Iowa State Agricultural College*, 11 October 1868 (Des Moines: Mills & Co., 1868), 3-5. Iowa State University Archives/Special Collections. Welch further examined the role of scientific education and support for co-education in his inaugural address. See Adonijah Welch, “Inaugural Address.” *Addresses Delivered at the Opening of the Iowa State Agricultural College, March 17, 1869* (Davenport: Gazette Premium book & Job Printing Establishment, 1869), 22-40. Iowa State University Archives/Special Collections.

²⁸ Adonijah Welch, “Inaugural Address.” *Addresses Delivered at the Opening of Iowa Agricultural College, March 17, 1869* (Davenport, Iowa: Gazette Premium Book & Job Printing Establishment, 1869): 26, 38-39.

²⁹ Earle D. Ross, “The Manual Labor Experiment in the Land-grant College.” *The Mississippi Valley Historical Review*, Vol. 21 (March 1935): 513-528.

the preservation of health, and the maintenance of the habits of industry.”³⁰ The trustees noted that previous attempts at including manual labor at college institutions arose because of student poverty and high tuition. They believed Iowa students would work industriously and efficiently to show their fellow students they all deserved proper respect, no matter their station in life.³¹ In 1876, an unnamed writer for the *Progressive Farmer*, most likely one of the contributing Iowa Agricultural College professors, noted, “the first thing a boy or girl learns on entering the Agricultural College is that the student most respected and most influential is that one who combines industry as a scholar with skill and perseverance as a worker.... I have heard this criticism of a student several times: ‘Yes a pretty good scholar, but never will he be worth much, because you see he shirks his work.’”³²

Much of the theory college leaders brought to the concept of manual labor had already been attempted at agricultural schools in the Northeast and in Michigan. Welch dismissed the failures and adhered to an educational philosophy and process that learning took place through visual and hands on experience.³³ He believed that the chief object of labor at an agricultural college should be educational and illustrate the principles of science that students learned in the classroom, while also enhancing a “taste for agricultural and mechanic pursuits.”³⁴ This applied to men and women. For men, Welch noted that the practice of horticultural arts supplemented the science of botany, soil experiments and fertilization

³⁰ *First Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm, January 1868* (Des Moines: F. M. Mills, State Printer, 1868): 10. Iowa State University Archives/Special Collections.

³¹ *First Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm, January 1868* (Des Moines: F. M. Mills, State Printer, 1868): 10. Iowa State University Archives/Special Collections.

³² “The Influence of Manual Labor on the character of students at the Agricultural College.” *Progressive Farmer*, Vol. 2 (February 1876): 23. Iowa State University Archives/Special Collections.

³³ Adonijah Welch, “The Kind of Higher Education Needed in the West,” Box 1, Folder 1/3, Addresses-not dated, address delivered at Nebraska University. Iowa State University Archives/Special Collections. Welch more fully developed his ideas in 1888 and 1889 in two addresses delivered to college students. Welch, “Talks on Psychology Applied to Teaching,” (1888) and “The Teacher’s Psychology,” (1889), Box 2, Folder 2/6, Addresses 1815-1889. Iowa State University Archives/Special Collections.

³⁴ *Second Biennial Report of the Trustees of the Iowa Agricultural College, January 27, 1868* (Des Moines: F. W. Palmer, State Printer, 1868): 36. Iowa State University Archives/Special Collections.

supported chemistry, and surveying involved the practice of mathematical principles. Welch wanted domestic economy instructors to show female students how to establish and maintain a healthy home and practice household duties efficiently.³⁵

Welch and college administrators further adapted the manual labor requirements in 1873. The main tenets of the labor system remained in force; work promoted learning, health, and morality. However, faculty had already begun introducing more instructive labor for the upperclassmen. All juniors and seniors, and sophomores in the spring term, undertook work that directly related to their course of study, such as surveying, animal breeding, tree grafting, or machine repair. The freshmen and sophomore students continued to work in the fields or maintain fences. Even though men saw more specialized work outside the classroom, the women remained tied to the laundry, dining room, and bakery before 1880. However, the matron could use her own discretion to place female students at the most needed work requirements, or the work best suited to the individual.³⁶

Manual labor in the fields and kitchens gave students practical hands on experience as well as providing a way to offset fees, living expenses, and other college costs, while providing the college with cheap, skilled labor. Manual labor also fit into the college motto, "Science with Practice." Liberal education gave students new knowledge, but they needed to reinforce that learning with farming and mechanic skills they might use after graduation. To that end, male students prepared college farmlands for planting in the spring, cultivated the crops through the summer, and then handled the harvest in the fall. Agricultural students also assisted with the college livestock, built and repaired fences, and worked in the college

³⁵ Adonijah Welch, "Inaugural Address." *Addresses Delivered at the Opening of Iowa Agricultural College March 17, 1869* (Davenport: Gazette Premium Book & Job Printing Establishment, 1869): 13. Iowa State University Archives/Special Collections.

³⁶ *Fifth Biennial Report of the Iowa State Agricultural College and Farm: 1874 to 1875* (Des Moines: R. P. Clarkson, State Printer, 1875): 42-43. Iowa State University Archives/Special Collections.

produce gardens. The college could then sell the cereal crops and livestock for profit and use the garden produce in the college kitchens. Those students in the mechanical disciplines, or those with skills in blacksmithing, worked in the college shops making tools or furniture for the college. They also assisted with building and road construction in and around the college grounds.³⁷

While the Board of Regents gave Welch and his faculty considerable leeway in operating the college and instructing the students, the general public needed additional assurances concerning the education of their children. Welch broadcast his philosophy to the Iowa public through numerous articles and addresses. In 1875, writing for the *Progressive Farmer*, he stated, “The new education takes an inventory of all the elements that make up success in life and wisely adjusts its course of studies. Our college courses give the future farmer and mechanic a full measure of artistic specialty, and a moderate amount of studies to prepare men for those wider duties incumbent on all.”³⁸ Welch placed science and practical experience first and foremost, but recognized the need for appropriate exposure to history, economics, and literature that provided adults with a cultural and social foundation as well. Welch envisioned a state supported by scientific farmers, well-trained mechanics, and professional engineers.

Throughout his term as college president, Welch continued to defend the policy of scientific and practical education he oversaw in Iowa. Welch refined his objectives when addressing the Board of Regents, stating, “The old theory which still prevails declares that

³⁷ *Biennial Reports of the Trustees of the Iowa Agricultural College, 1868-1880* (Des Moines: F. W. Palmer, State Printer, 1868). Every year between 1868 and 1880 the college president listed the manual labor requirement as part of the college curriculum. In his report to the secretary he would detail some of the activities of the students during the past year. Though not every year, the treasurers report would sometimes detail the amount paid out to students and for work they performed.

³⁸ Adonijah Welch, “Industrial Education,” *The Progressive Farmer*, Vol. 1, No. 1 (January 1875): 5. Iowa State University Archives/Special Collections.

learning should be taught for the culture it affords. The new theory which we have adopted affirms that knowledge should be taught for its uses.”³⁹ Welch repeatedly brought out the language of the Morrill Act, noting that it required instruction in “industrial sciences”, not “industrial arts”, distinguishing the trades and handicrafts from the underlying principles. He believed the province of the national land-grant colleges, as defined by the law, was not to develop “carpenters, masons, plowmen and crop raisers merely, but architects, engineers, scientific breeders, veterinary surgeons, economic entomologists and the like.”⁴⁰ Welch strongly adhered to the system of science with practice and hired faculty who shared his vision.

Seaman Knapp and Charles Bessey steadfastly remained two of the strongest proponents for Welch’s vision. Knapp, known widely as the founder of farm demonstration work, favored a slightly more practical approach to learning, stating “Our first reason for enlarging industrial education is to make a well balanced, practical man. Our second reason is the direct bearing it has upon practical life.” However, applied research necessitated a solid understanding of scientific principles. He held that intelligence and practical ability resulted in skill, requiring training in thought, careful observation, a good memory, and reflection and reason. He placed all of these qualities as hallmarks of the “new education” and the cornerstone of the land-grant colleges.⁴¹

³⁹ Adonijah Welch, “President’s Report,” *Fourth Biennial Report of the Iowa Agricultural College and Farm, December 1871* (Des Moines: G.W. Edwards, State Printer, 1872): 9. Iowa State University Archives/Special Collections.

⁴⁰ Adonijah Welch, “The True Work of National Industrial Schools,” *Seventh Biennial Report of Iowa State Agricultural College and Farm, 1876-1877* (Des Moines: R.P. Clarkson, 1877): 43-44. Iowa State University Archives/Special Collections.

⁴¹ Seaman Knapp, “Let Us Enlarge the Domain of Industrial Knowledge,” *An Address at Mississippi Agricultural and Mechanical College, June 20, 1894* (Starkville: E.L. Reid, 1894): 5-10. Iowa State University Archives/Special Collections.

In 1858, Iowa Agricultural College organizers included surveying and mechanical arts directly related to agriculture in the proposed course of instruction. Early supporters also demanded students acquire adequate comprehension of technical principles so they could properly perform practical applications of technical knowledge. Educators felt the liberal education they supported naturally included manual labor, employing classroom principles in practical applications.⁴² Students would develop an educational foundation based on technical principles and enhance their overall educational experience with workshop training.

However, the math and science instruction that students across the nation received prior to attending college varied greatly. Students in eastern regions benefited from more highly trained teachers at the primary level, and wider access to schooling in general. Students in more rural areas, like Ames, Iowa, obtained almost no science and only rudimentary mathematics training.

While Eastern educators had elaborate plans and programs to educate Americans⁴³, Iowa common school administrators operated largely based on local needs before 1890. Communities developed educational styles and methods based on what young boys and girls might need to operate a farm or small business. Students in Ames, Iowa, probably experienced one of the more progressive systems due to the town's proximity to the college.

In Ames, the common school administrators published the course of instruction in the local paper shortly before fall classes commenced in 1877. Concerning mathematics and sciences, first year students learned counting 1 to 100 and simple addition. Second and third

⁴² *First Annual Report of the Secretary of Iowa State Agriculture College: For the Years 1858 to 1859*, (Des Moines: John Teesdale, State Printer, 1859): 8-10. Iowa State University Archives/Special Collections.

⁴³ Robert H. Thurston designed and elaborated on much of the educational system for engineering at Cornell University and in the East in the 1870s and 1880s. Some of his more insightful works on the subject of education included "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872): 17-25, "Instruction in Mechanical Engineering." *Scientific American Supplement*, Vol. 17 (1884): 6904-6905, and "Education of the American Citizen." *Scientific American Supplement*, Vol. 21 (1886): 8368-8370.

year students practiced notation and numeration, learned Roman numerals, and developed multiplication and division skills. Higher level classes included percentages, powers, and finally in their last year, students learned elementary algebra. In their last year, students learned basic physiology and physical geography, the only science listed for any level.⁴⁴ Under this course of instruction, most students could keep account books and understand everyday mathematics they might encounter. However, anyone who did not complete the final year of common school instruction would not have been able to determine areas from dimensions or solve more complex mathematical problems involving unknown quantities. Since many of the teachers came straight from the common school, their skills in mathematics and science principles often left students lacking in appropriate instruction.

College professors helped alleviate the disparity between common school instruction and collegiate expectations during the early years of the college by giving lectures to area teachers on classroom methods. Charles Bessey, professor of botany and horticulture, lectured on the elementary teaching of sciences in the common schools for local teachers a few weeks before classes met in 1877. Reports indicated that Bessey used practical methods of piquing student interest, and asserted that “moderately well read” individuals in botany, chemistry, and physics could successfully employ Bessey’s ideas.⁴⁵

Since the Iowa Agricultural Colleges professors had almost no way of knowing exactly what level of mathematics and science instruction incoming students had obtained, instructors kept a close watch on applicant entrance exam scores. Entrance requirements at the college required students to demonstrate basic knowledge in geography, grammar, English analysis, spelling, arithmetic and algebra. College personnel helped schools and students

⁴⁴ “Course of Instruction.” *The Ames Intelligencer*, 14 September 1877: 3. The Ames Public Library Collection.

⁴⁵ *The Ames Intelligencer*, 24 August 1877: 1. The Ames Public Library Collection.

prepare for admission by including example questions in the biennial reports and college catalogue, including twice as many mathematics questions in the samples. However, college applicants only needed the most basic knowledge in geography to complete what was labeled as the science portion of the exam. Those applicants who did not pass the entrance exam took at least one semester of preparatory coursework, including English grammar, geography, arithmetic, elementary algebra, and elementary geometry. The preparatory classes consisted of between 6 and 22 students each year until well into the 1890s, even though the college officially ended the preparatory program in 1883.⁴⁶

Iowa Agricultural College borrowed many of its examination questions from the Sheffield Scientific School, a part of Yale College and one of the noted models for organization at Iowa Agricultural College. Sheffield examinations in the 1860s included arithmetic, algebra, geometry, plane trigonometry, Latin, United States history, geography, and English grammar. In 1866, fifty-one candidates sat for examinations at Sheffield, and only thirteen gained unconditional admittance and five failed completely. Since its approach provided an organizational model for many other colleges, Sheffield helped to enforce higher standards nationwide.⁴⁷

Not only did Sheffield Scientific School provide an educational model for new colleges, it was also the training ground for a number of professors, including future Iowa Agricultural College professors William Anthony and George Jones in physics and mathematics, respectively. Sheffield-trained professors, like Anthony and Jones, stressed that

⁴⁶ *Seventh Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm, 1876-1877* (Des Moines: R. P. Clarkson, State Printer, 1877): 33-34. Iowa State University Archives/Special Collections. The college published samples of entrance examination questions from 1876 until 1880 in the *Biennial Reports*. They began listing them in the college *Catalogues* in 1881 and continued providing sample questions in that publication until 1883.

⁴⁷ Russell Chittenden, *History of the Sheffield Scientific School of Yale University, 1846-1922*, Vol. I (New Haven: Yale University Press, 1928): 125-126.

coursework taught “the principles of science, the laws of its application, and the right methods of research”, while also providing “something of that literary culture which is imparted in good classical college.”⁴⁸ Though Sheffield educators focused on scientific coursework, they realized that classical studies broadened the students’ horizons and allowed them a greater avenue of application in American society. Anthony and Jones brought this philosophy with them, influencing development of well rounded students in Iowa, many of whom went on to college teaching positions themselves.

The Sheffield governing board members repeatedly clarified the position they hoped their school would occupy amongst the growing number of technical and science oriented schools. They promoted high scholarship standards, focused on being a school of science rather than a purely technical school, and sought a distinctive character to separate Sheffield from other schools of science. Board members supported the idea that state colleges founded under the 1862 Morrill Act would necessarily focus on regional needs. The agricultural states of the Midwest and Great Plains gave special attention to practical agricultural training. Colleges in mining states would focus on mining engineering. In the East, educators could focus on “the instruction of engineers, mechanics, chemists, and the directors and superintendents of great manufacturing establishments.”⁴⁹ Sheffield administrators hoped to

⁴⁸ Russell Chittenden, *History of the Sheffield Scientific School of Yale University, 1846-1922*, Vol. I (New Haven: Yale University Press, 1928): 143.

⁴⁹ Russell Chittenden, *History of the Sheffield Scientific School of Yale University, 1846-1922*, Vol. I (New Haven: Yale University Press, 1928): 144. The trustees at Sheffield realized in order to develop the kind of students they desired, innovative and charismatic professors needed to organize programs of study integrating theoretical principles and practical applications. William Trowbridge, professor of dynamical engineering, felt the theoretical principles which lay at the foundation of successful implementation of practice had become disregarded in favor of purely practical training. Students who only operated machinery might eventually learn the finer details of the machinery, but they only learned an art and use of tools. Those young men who obtained positions in drawing or design rooms spent their work hours tracing others’ work, never learning the fundamental principles involved. On the other hand, students who acquired thorough knowledge in principles and the rules of application prepared themselves for innumerable situations they might encounter. Principles and applications for scientific areas involving thermodynamics, mechanics, and electricity showed constantly changing situations that a student would possibly encounter, what Trowbridge called “dynamical science.”

fill this niche, providing technically trained professionals in the East who could disperse to other science oriented institutions.

Eastern models of technical education, as found at Sheffield and Cornell, provided administrators at Iowa's land-grant college with a great deal of useful information concerning curricula, teaching philosophy, and practical instruction. But as interesting as the comprehensive approach used by Cornell and the Sheffield Scientific School seemed, Iowa administrators faced a troublesome shortage of college educated professors capable of implementing such a system. Many of those who served as early instructors in Iowa's classrooms brought years of farming, mechanical, or engineering experience, rather than Sheffield's or Cornell's comprehensive preparation. In fact, by 1880 Iowa Agricultural College had hired at least a dozen of its own graduates as instructors and classroom assistants.⁵⁰ Larger, better established universities had to matriculate teachers in the 1870s and 1880s to fill the demand as schools in the Midwest and West grew.⁵¹ These colleges also had to replace professors who left for more lucrative positions at other schools and businesses.

Despite frequent turnover in professors and limited laboratory and workshop experience, the years before 1883 also marked the steady development of theoretical and applied science education for Iowa college students under the auspices of two majors, agriculture or mechanic arts. Those students entering mechanics faced a course of instruction made up mostly of engineering courses. However, the design of engineering instruction at Iowa Agricultural College incorporated both theoretical science methods and applied training in the laboratory and shop.

Students received instruction through lectures and "the written experiences, deductions, and classifications of the most eminent writers." See William Trowbridge, *Inaugural Address before the Sheffield Scientific School of Yale College, October 5, 1870* (Philadelphia: Henry Carey Baird, Industrial Publisher, 1871): 7-8, 9-10.

⁵⁰ "Professors." *History and Reminiscences of I.A.C.* (Des Moines: Press of The Geo. A. Miller Printing and Publishing Co., 1897), 211-256.

⁵¹ Earle D. Ross, *The Land-Grant Idea at Iowa State College* (Ames: The Iowa State College Press, 1958), 53.

A year before the first class graduated in 1872, William Anthony, professor of physics and mechanics, and George Jones, professor of mathematics and civil engineering, decided mechanical and civil engineering required different methods of practical training. Despite the differences in applied focus, each group of students took algebra, geometry, trigonometry, physics, and chemistry to provide them with a mathematical and scientific foundation. However, mechanical engineering students needed additional course work relating to machine theory and drawing. Civil engineering students required course work on roadbed construction, railroad surveying, and bridge building.⁵²

To facilitate student training on machinery and in drawing design, Professor Anthony requested more funding for the mechanics workshop after his first year of teaching so that he could supplement his classroom lectures with hands on experience for the students. His Sheffield training undoubtedly allowed him teach principles effectively, but that same training insisted on applied coursework to complement the theory. He kept his requests as limited as possible in terms of instructive apparatus and machinery for the workshop, but his requests also fell under the needs of the physical plant for the college. College buildings needed boilers for heating, and machines required steam engines for power. Anthony also asked for, and on a limited scale received, lathes and machining tools so students could practice trade skills.⁵³

Professor Anthony's approach to mechanical engineering contained both the theoretical and workshop disciplines of the field. During the first two years of instruction, he first emphasized the theoretical understanding of scientific and mechanical principles. During

⁵² *Fourth Biennial Report for the Agricultural College and Farm, December, 1871* (Des Moines: G. W. Edwards, State Printer, 1872), 11. Iowa State University Archives/Special Collections.

⁵³ *Fourth Biennial Report for the Agricultural College and Farm, December, 1871* (Des Moines: G. W. Edwards, State Printer, 1872), 128-129. Iowa State University Archives/Special Collections.

their manual labor hours of their sophomore and junior years, students learned machine operation and tool use. During the senior year of course work, students integrated theory and application by studying machine theory and designing instruments based on the fundamental principles they had previously learned.⁵⁴

Alexander Thomson continued Anthony's teaching methodology after Anthony departed in 1872 due to disagreements with the administration over compensation and research funding.⁵⁵ Thomson and John Macomber, the new physics instructor, stressed the need for all students to understand theoretical principles before entering the machine shop or laboratory. Workshop activities remained primarily an upper level course, and students did not begin machine design until their senior year.⁵⁶

In 1875, Professor Thomson clarified the two main components of mechanical instruction at the Iowa Agricultural College. Students received theoretical instruction through the use of lectures, recitation, and readings. They gained practical training by completing laboratory or workshop projects utilizing the available materials and equipment. Thomson felt he needed to clarify these points because of confusion between coursework and shop instruction. Thomson made a point to mention in his reports to President Welch and the Board of Regents that shop work included machine design, machine and tool use, and steam engine operation.⁵⁷

⁵⁴ *Fourth Biennial Report for the Agricultural College and Farm, December, 1871* (Des Moines: G. W. Edwards, State Printer, 1872), 34, 42-43. Iowa State University Archives/Special Collections.

⁵⁵ Earle D. Ross, *A History of Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 79, 93. Anthony resigned over a disagreement about compensation for installing laboratory equipment in the summer months and misunderstanding regarding his opportunities for personal research in 1872. He took a position as mechanics and physics instructor at the New York Agricultural College at Cornell in 1873.

⁵⁶ *Fifth Biennial Report of the Iowa Agricultural College and Farm, 1872-1873* (Des Moines: R. P. Clarkson, State Printer, 1873), 14-22, 49, 61-62. Iowa State University Archives/Special Collections.

⁵⁷ *Sixth Biennial Report of the Iowa State Agricultural College and Farm: 1874-1875* (Des Moines, Iowa: R. P. Clarkson, State Printer, 1875), 81. Iowa State University Archives/Special Collections. Essentially, Thomson promoted the engineering curriculums practical training aspects to assuage the rural opposition to college

Even though he clarified the distinction between theory and practice for mechanics students, Thomson continued to stress the importance of maintaining a balance between the two. He noted the object of the courses in mechanical engineering was to “impart the scientific knowledge and practical skill which are essential to success in mechanical engineering. This necessarily implied a thorough mastery of the principles of mathematics and a diligent study of their application to the construction of machines.” Thomson did not focus only on engineering instruction. He included all scientific coursework in his teaching philosophy, noting that, “Technical instruction aims to furnish the means for obtaining a liberal and practical education.”⁵⁸ Thomson’s methodology in the classroom and shop encouraged students to learn a wide variety of subjects and apply that knowledge in an appropriate manner towards their coursework and practical training.

Thomson developed his own style of integrating the principles taught in the classroom with the proper applications of those principles. However, students did not practice brand new shop methods. The machine shop used a modified form of the plan adopted by the Russian government, and made popular in the United States following its demonstration at the 1876 Centennial Exposition in Philadelphia. Students were given hand tools to perform a series of exercises that resulted in the pieces for a model or small machine. This plan provided the shop with multiple small steam engines and tools for future use by the students

training that had arisen in 1873 when the state legislature investigated the classroom operations and expense reports of the college. While opponents blamed the administration and faculty for not catching the fraudulent activities of the assessor, the Board of Regents concluded that the college personnel had nothing to do with the lost money and the operations of the college were sound. See the *Fifth Biennial Report of the Iowa Agricultural College and Farm, 1872-1873* (Des Moines: R. P. Clarkson, State Printer, 1873): 80-100. Iowa State University Archives/Special Collections. The following articles in the *Story County Representative* also detailed the legislative comments and responses by President Welch: “President Welch before the Rankin Investigation Committee.” 6 February 1873; “Report of the Rankin Investigation Committee.” 20 February 1873; “State Agricultural College, Address by Welch before legislature on Rankin Committee Report.” 6 March 1873; “The Agricultural College.” 4 June 1873; and “The Agricultural College, Report of the Legislative Committee Investigation.” 26 March 1874. The Ames Public Library Collection.

⁵⁸ *Iowa Agricultural College Catalogue, 1880* (Ames: Published by the College, 1880), 28. Iowa State University Archives/Special Collections.

in the shop. The standard equipment for the Russian method included files, squares, calipers, gauges, lathes, planers, drill-presses, and drills. This type of work resulted in a self-sufficient workshop, but students could not create large scale projects since each person worked individually. The Russian method required little in the way of skilled or trained technicians to operate the machine shop, which worked well with Thomson's philosophy. He liked to check in with each student, instead of being tied to one machine or apparatus giving instruction.⁵⁹

One can truly begin to see the influence of professors like Anthony and Thomson through required senior theses beginning in 1878. Students demonstrated both their knowledge of theoretical principles and how those principles played out in the laboratory and workshop. Between 1878 and 1882, students wrote science theses on electrical induction, biological plant classification, industrial water supply, waterways and drainage, foundry work, celestial dynamics, tornadoes, and the transmission of electricity.⁶⁰ Students included basic knowledge of the subject and usually provided experimental results from their senior laboratory or shop work.

The nature of student work shows a distinct correlation between Welch's mission of theoretical science education coupled with utility and practical preparation. Students learned science and demonstrated their knowledge in detailed and informative senior theses. In 1878, Ellen Rice, one of the first female students to complete the science curriculum, titled her work "Electrical Currents of Induction." She described the methods of producing induced currents and the properties exhibited in the laboratory. Rice also explained the chemical reaction

⁵⁹ *Seventh Biennial Report of the Iowa State Agricultural College and Farm: 1876-1877* (Des Moines, Iowa: R. P. Clarkson, State Printer, 1877), 88. Iowa State University Archives/Special Collections. Little has been written about the development of the Russian System or its introduction into Europe or the United State. The most complete description remains chapter 1 of Charles A. Bennett, *History of Manual and Industrial Education, 1870-1917* (Peoria, IL: The Manual Arts Press, 1937), 1-47. The Russian Method's introduction to the United States is mentioned on page 42.

⁶⁰ *Author-Title Index of Bachelor Theses 1878-1923*, 1-10. Iowa State University Archives/Special Collections.

equations of a galvanic battery and explained how energy conservation worked. She applied her knowledge of induced currents to experiments she conducted in the college laboratory on a telephone, then a fairly new technology and thus indicative of the innovative nature of Iowa Agricultural College's curriculum. Rice finished her thesis with power output calculations and comparisons between Niagara Falls and induction current motors. Rice demonstrated a detailed knowledge of physical concepts, writing on a technical subject in a technical manner which included mathematical processes and scientific concepts.⁶¹

Other students also demonstrated a strong background in mathematical and scientific principles before 1883. J.C. Meredith examined wind power in his 1878 thesis "Wind as a Motor." Meredith began by examining how various natural phenomena created wind. He focused on three specific causes; heating and cooling of air, the earth's rotation, and the attraction of the Sun and Moon on a periodic cycle. Meredith then developed a detailed mathematical derivation for wind acceleration and pressure, using integral calculus. After finding the appropriate forces caused by wind, he sketched out the construction of a windmill house based on his calculations.⁶²

Meredith showed the most advanced mathematical skills of any student before 1890, man or woman. However, he applied only theory to his constructed arguments. He never mentioned or explained any lab work based on his calculations or sketches. Charles Mount and Willis Whited wrote their theses with practical application in mind. Charles Mount examined the construction of sewer systems in his 1878 thesis, "Sanitary Engineering." Before describing the construction of a sewer system, Mount detailed the various physical and geological characteristics that sanitary engineering had to take into account, including soil

⁶¹ Ellen Rice, "Electric Currents of Induction." *Theses 1878*. Iowa State University Archives/Special Collections.

⁶² J.C. Meredith, "Wind as a Motor." *Theses 1878*. Iowa State University Archives/Special Collections.

type, amount of rainfall, population size, and construction materials. Mount took each of these characteristics into account when he made his calculations for water volume and speed, chemical composition of sewage, and sewer duct dimensions. He even concluded with a short description of diseases associated with poor sanitary works, such as malaria, cholera, and yellow fever.⁶³ After graduation, Mount became the civil engineering instructor at the college until 1890. He then left to become a civil engineering manager for a business in Cleveland, Ohio.⁶⁴

Mount demonstrated a broad scientific knowledge, incorporating mathematics, civil engineering, materials testing, geology, physics, and biology. He created a thesis that portrayed what he had learned in numerous science classes and laboratories, while also creating a plan that sold his skills to cities and towns needing new and improved sanitation works. Willis Whited focused his work on grain elevators for farmers in 1879. Where most students tended to provide a lengthy history of their topic, Whited described the contemporary machinery and its uses. He performed calculations for elevator size, grain speed, and storage bin size. However, Whited found that calculations alone did not account for all the variables present in a contemporary agricultural grain elevator. Farmers and interested scientists would have to create extensive tables for grain speed, pipe radius, and elevator length before practical applications could provide for optimal efficiency. Whited did not provide a finished example like Mount, but he did demonstrate that farmers required detailed equipment analysis and useful experimental tables.⁶⁵

⁶³ Charles F. Mount, "Sanitary Engineering." *Theses 1878*. Iowa State University Archives/Special Collections.

⁶⁴ *History and Reminiscences of I.A.C.* (Des Moines, Iowa: Press of The Geo. A. Miller Printing and Publishing Co., 1897), 221.

⁶⁵ Willis Whited, "Elevator Machinery." *Theses 1879*. Iowa State University Archives/Special Collections.

Between 1868 and 1882, Welch and his hand-picked faculty promoted the college through their official reports and numerous lectures. The college community also received a tremendous amount of positive feedback on the new college through the local newspaper. Editors praised the concept of “science with practice”, accepting it as “our watchword, or ideal, the realization of which will be our first, our highest object.”⁶⁶ Addressing the debate between old and new educational styles in the college newspaper, students attempted to bring the benefits of old education’s “culture” and new education’s “useful knowledge” closer together. Editors and article writers posited that the new education “put useful tools into the young man’s hands and teaches him their use; the old enlivened and strengthened the man himself.” The public had to trust that the college faculty would provide students with useful, cultured instruction that in the end improved all aspects of society through better agriculture and better engineering. The absence of public discontent in the second half of the 1870s, suggests that the faculty and student articles placated the general public.⁶⁷

Charles Bessey, one of Welch’s early faculty hires for botany and horticulture, and who would later become the driving force behind the University of Nebraska’s industrial education department, was one such defender of the idea that scientific study prepared men to pursue science careers after college as teachers, botanists, horticulturists, surveyors, or engineers. Bessey strongly believed schools of science and engineering gave students the ability to acquire new knowledge over time, rather than handing it to them all at once. He saw this as particularly important for new engineers who might encounter any number of unique problems in their post-college careers. He wanted the Iowa Agricultural College, as well as any other properly motivated school, to build more laboratories for chemistry, physics,

⁶⁶ “Announcements,” *Ames Intelligencer*, Vol. 1, No. 1 (June 1873): 2. The Ames Public Library Collection.

⁶⁷ “The Old and the New,” *The Aurora*, Vol. 1, No. 4 (September 1873): 2. Iowa State University Archives/Special Collections.

biology, and geology where students could explore scientific principles. Bessey, always the consummate educator, relished the opportunities to give “suggestive lectures” when students brought in fossils or plants. He wanted students fully engaged in the classroom, and found that because of his efforts he was more engaged in the classroom and with his students.⁶⁸

Alexander Thomson, the replacement for William Anthony in physics and mechanics, emphasized the importance of keeping technically trained engineers in the state of Iowa, and noted that the state’s growing mechanical industries were in desperate need of qualified engineers. Playing on lawmakers’ competitive spirits, Thomson reported that schools in Minnesota, Wisconsin, and Kansas had all built new engineering buildings costing more than \$9,000 each. Illinois Industrial University had acquired \$25,000 from their state to build and equip a new mechanical laboratory. Iowa’s administrators and professors knew that popular and effective teaching methods would not always provide the deciding factor for students on whether or not they should attend college.⁶⁹ In 1881, the Board of Regents appropriated \$5000 for the new engineering building, but that only completed part of the building, and left nothing for the furnishing of equipment and furniture. The college did add Fremont Turner to the staff that year as the foreman and teacher in the engineering workshop, freeing Thomson from many of his shop duties and allowing him to spend more time in the classroom.⁷⁰ Thomson left academia to accept a series of administrative positions with several businesses beginning in 1884. His legacy remained with his students, like Ellen Rice, Ida Twitchell, Charles Mount, and Willis Whited, who had completed their studies without most of the new renovations. Despite these apparent hardships, those students’ work did exemplify how

⁶⁸ Charles Bessey, “On a Scientific Course of Study.” *The Aurora*, Vol. 5, No. 2 (May 1877): 5-6. Iowa State University Archives/Special Collections.

⁶⁹ *Ninth Biennial Report of the Iowa State Agricultural College and Farm: 1880-1881* (Des Moines: F. M. Mills, State Printer, 1881): 10, 30-31. Iowa State University Archives/Special Collections.

⁷⁰ *Iowa Agricultural College Catalogue, 1881* (Ames: Published by the College, 1881): 33. Iowa State University Archives/Special Collections.

students learned scientific principles and their practical applications in the lab and real world at Iowa Agricultural College prior to 1883. They learned principles in the classroom and then applied them in the laboratory or workshop. However, the college's learning emphasis shifted dramatically and suddenly in 1883 when several administrative, faculty, and staff changes occurred. Though students continued to produce scientific expositions, the

Public dissatisfaction with the Agricultural College ebbed and flowed throughout the 1870s and 1880s. In 1884, following the dismissal and resignation of Welch as president and the hiring of several new professors, the General Assembly redefined the college mission so that it adhered more closely to the 1862 Morrill Act. Legislators argued that the 1858 Act which established the agricultural college had improperly limited the true purpose and intent of the 1862 Morrill Act legislation. They insisted that a broad, liberal curriculum and training regimen that relied on modern literature and sciences, including social sciences, had to have a prominent place. The tension between legislators and college personnel continued through the 1880s, leading to a progression of different faculty members and instructional methods.⁷¹

Seaman Knapp's adherence to a balanced educational approach that included both theoretical classroom work and applied practical instruction was severely tested in 1883, when he became the acting president of the college for one year. He acquiesced to public demands for wholly practical trained farmers and engineers, initiating a decade of unrest and educational imbalance. New professors replaced laboratory experience with shop work and production training. Agricultural students returned to the farms before graduating, and

⁷¹ Earle D. Ross. *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 98-106, 118-119. Adonijah Welch stepped down as the college's president in 1883 following a year spent in Europe at the request of the Commissioner of Agriculture where he studied the agricultural schools of Europe. Welch's trip initiated a flurry of administrative changes involving numerous professors throughout the college. Upon returning to Ames, Welch accepted a limited teaching and lecturing position with the college from 1884 to 1887. Welch took a permanent leave after the 1887 school year to take a recuperative trip to California. He died there in the late summer of 1889, and was buried in Ames at the campus cemetery that fall.

engineering graduates rarely rose above the level of draftsmen or mechanic following graduation. However, by the early 1890s, new administrators and faculty, and the rise of professional organization helped restore the balance between scientific understanding and practical experience.⁷²

The Board of Trustees removed Adonijah Welch from the president's office in 1883 and replaced him with Seaman Knapp, a proponent of education based on experience. In 1885, the Board selected Leigh Hunt, but his tenure proved more disastrous than either Welch's or Knapp's. The college found some administrative stability in 1886 with the Board's election of William Chamberlain, a noted supporter of practical agriculture, experimental investigations, and leading contributor to the development of farmer's institutes. Though Chamberlain appointed successful humanities faculty during his tenure, his choices for engineering and agricultural professors proved to be more interested in business activities than educational or collegiate endeavors.⁷³

During this period of tension surrounding the college's mission, 1883 to 1887 marked a period of practical, shop-oriented teaching. Norman Bassett, a graduate of Worcester

⁷² On Seaman Knapp's philosophy and teaching career see Joseph Cannon Bailey, *Seaman A. Knapp: Schoolmaster of American Agriculture* (New York: Columbia University Press, 1945), 44-108. After a year as president, and one more as the head of the agricultural department, Knapp secured a leave of absence to establish a rice plantation in Louisiana, where he ended his teaching career. See also Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 102-103.

⁷³ On Knapp's support of practical and experiential education see Joseph Cannon Bailey, *Seaman A. Knapp: Schoolmaster of American Agriculture* (New York: Columbia University Press, 1948): 106. He wrote "Let us change the universal tendency to make scholarship general and theoretical and let us make our lines of investigation intensely practical. Too many of our scientists are seeking, after something foreign and remote, or peculiar and astonishing, and are averse to teaching the science of the farm....Chemistry and physics should be pulled off their high horses, thoroughly spanked, and set to farming." See also, Seaman Knapp, "The limits of Education, Under the Law, at Our Agricultural Colleges." *Department of Agriculture Miscellaneous Special Report No. 9* (Washington, D.C., 1885): 163-168. Leigh Hunt clashed with the Ames college culture from the start. In 1915 he summed up his educational views by stating, "We are over-educated. Our institutions of learning are for the few. Quoted in, Earle D. Ross. *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 104-106. William Chamberlain oversaw a succession of faculty hires between 1886 and 1890, primarily attempting to repair the damage done by poor faculty hires earlier in the decade. While Chamberlain succeeded in placing quality faculty in the humanities, his hires for technical positions proved disappointing. See Earle D. Ross, *A History of The Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 107-110.

Polytechnic Institute, home to the Worcester Method of shop work, came to Iowa in 1884 and immediately took control of the shops and the physical science and drawing courses.

Bassett's implementation of the Worcester Method meant more shop training to produce useable goods and less classroom study. Students who had prospered under the methodology of Thomson by complementing science principles with practical applications, suddenly found themselves spending all their time in the shop and wondering why they needed grounding in theory at all.⁷⁴

Bassett thought very little of the Russian method of training utilized by Anthony and Thompson before 1883. Bassett felt the exercises resulting in the production of a tool or piece of machinery wasted the student's time. By 1886, mechanical engineering course listings showed a distinct emphasis on workshop training over technical theory and principles.⁷⁵ The theoretical view of mechanical engineering was obviously not a priority for Bassett, even if he did state that "care is taken that the methods of applying the methods of applying principle to practice are thoroughly understood by the student."⁷⁶ Students picked up on his proclivities quickly. Clem Kimball, an 1889 graduate, remembered, "He was fond of practical methods and results, and found no time or had little inclination to devote to difficult theorems and analyses..." Kimball also remarked, "With all due respect to him, and although bright, clear and forcible in demonstration, Professor Bassett was not fitted for teaching. He was

⁷⁴ *Biennial Report of the Board of Trustees 1883-1886* (Des Moines: State Publisher, 1883-1886). Iowa State University Archives/Special Collections. Each department head submitted a yearly report. Professors often listed what research they had been involved with, what students did in their classrooms and laboratories, listed expenses they had incurred and proposed spending for the next fiscal year. These reports illuminate the teaching methods and how they changed over time.

⁷⁵ *Iowa State College of Agriculture and Mechanic Arts Catalogue, 1886* (Ames: Published by the College, 1886), 42. Iowa State University Archives/Special Collections.

⁷⁶ *Eleventh Biennial Report of the Iowa Agricultural College and Farm, 1884-1885* (Des Moines: George E. Roberts, State Printer, 1885), 27-28. Iowa State University Archives/Special Collections.

eminently fitted for designing, testing, and inventing machinery.”⁷⁷ Students evidently liked Bassett’s personality but not his teaching methods and emphasis.

Bassett instituted a manufacturing system within the college shop similar to the one developed in Worcester, Massachusetts.⁷⁸ His students produced twenty-eight drawing desks, tool cases, work-benches, and various other pieces of furniture and equipment for the college by the end of his first year at Iowa Agricultural College. Bassett fully intended to produce tools, machinery, and various other apparatuses that would fully equip the shop in order to begin manufacturing products for the market. This application of production in the shop, if done carefully, would be more efficient and incur less cost than the system Thomson had employed, and according to Bassett, brought the college in line with other “leading engineering schools”.⁷⁹ But students displayed a steadily decreasing knowledge of foundational principles in their written work.

Under Bassett’s direction, men’s studies became decidedly practical and applied with little discussion or development of underlying principles. Male students focused their work in the sciences on applications and construction, often building college furniture and equipment. Titles of student theses from these years included: “A Pratt Truss Bridge”, “Water Supply for Towns”, “Drainage and Sewage”, and “High Speed Engines”. Bassett’s students knew how to make a bridge or sewer system, but they rarely made mention of the calculations and underlying principles needed for the projects.⁸⁰

⁷⁷ *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1887), 133.

⁷⁸ *Twelfth Biennial Report of the Iowa Agricultural College and Farm, 1886-1887* (Des Moines: George E. Roberts, State Printer, 1887), 47. Iowa State University Archives/Special Collections.

⁷⁹ *Eleventh Biennial Report of the Iowa Agricultural College and Farm, 1884-1885* (Des Moines: George E. Roberts, State Printer, 1885), 28. Iowa State University Archives/Special Collections.

⁸⁰ *Theses 1883-1887*. Iowa State University Archives/Special Collections.

Several students' experiences demonstrated the changing nature of utilizing applied and practical knowledge during the 1880s. In his 1886 thesis, James W. Bradford examined the construction techniques for a Pratt Truss Bridge. He spoke about the history of the bridge and its most useful applications. In addition, he also provided sketches of the bridge work, showing the reader what the bridge would look like after completion.⁸¹ However, Bradford did not demonstrate that he knew the necessary mathematical processes needed in the construction of the bridge, including geometrical measurements, analytical stress testing, or basic algebraic force measurements for a structure submitted to differing kinds of weight loads. This did not mean that Bradford could not perform the necessary mathematics or apply the necessary scientific principles, but neither did he show he could do them. Bradford went on to become a teacher in Nashua, Iowa, and a junior member of the Bradford and Sons furniture dealership in 1891.⁸²

George Schermerhorn examined high speed engines in 1887, performing several experimental trials on homemade models. When he wrote to family members, he made sure to mention the extended time he spent in the workshop each month completing projects.⁸³ Schermerhorn never sounded resentful about his many hours working at the lathe, forge, or other machinery, but he did not show the kind of enthusiasm for this manual labor as he expressed for electricity, astronomy, or geology. Regardless of his fondness for science theory, Schermerhorn completed the construction of his high speed engine and obtained the experimental results he needed to finish writing his graduation thesis. He did not develop the mathematical derivations, physical, or engineering principles needed for engine design.

⁸¹ James W. Bradford, "A Pratt Truss Bridge." *Theses 1886*. Iowa State University Archives/Special Collections.

⁸² Wheeler, "History of I.A.C. Alumni." *Aurora*, Vol. 20 (July 1891): 26. Iowa State University Archives/Special Collections.

⁸³ Earle Ross, "Letters of an Engineering Student in the 1880s." *Annals of Iowa* (Fall 1960): 438-453.

Schermerhorn simply built the engine based on published designs and tested the apparatus in the shop.⁸⁴

Bassett organized his classes around shop instruction and completion of useable projects. Students like Bradford and Schermerhorn necessarily knew more about construction techniques than they did about the scientific principles underlying those techniques. Men demonstrated this change in educational method by focusing on the practical application of engineering projects. The change in focus implemented by Bassett also meant that the number of women entering the physical science classes dropped precipitously.⁸⁵

⁸⁴ George Schermerhorn, "High Speed Engines." *Theses 1887*. Iowa State University Archives/Special Collections.

⁸⁵ With the de-emphasizing of science theory and less classroom learning in the physical sciences, coupled with the creation of a specialized domestic economy program, women began focusing on biological sciences and literature. Iowa Agricultural College staff had begun providing domestic chemistry for ladies in 1871, Mary Welch supplemented the practice work with lectures. Welch and Mary Lovelace provided lectures and practical supervision in cooking, sewing, laundry, nursing, child rearing, and home management until 1883. Emma Ewing took charge of the new Domestic Economy program in 1884, which formally organized the haphazard education for women existing to that point. See Earle D. Ross, *A History of Iowa State College of Agriculture and Mechanic Arts* (Ames, Iowa: The Iowa State College Press, 1942): 130-131.

Women's Theses titles focused on the purple thistle, parasitic fungi, cone bearing trees, the nervous system, home science, and educational methods and psychology. Women's written work became decidedly less technical and more descriptive. Their theses contained fewer descriptions of biological or chemical principles. Women also began justifying their education as complimentary or supportive of their future work in the women's sphere of home and family. See *Theses 1883-1887*. Iowa State University Archives/Special Collections.

Before the 1883 curriculum changes took place, Agatha West provided the best example of scientifically based domestic education, aimed at advocating the duties of women in the home. Her thesis described the scientific, business, and humanities knowledge women required to run an efficient home while also raising and educating their children. Science didn't just improve the home. It also provided the basis from which to construct new methods and philosophies for domestic duties. See Agatha M. West, "Education of Women for the Home." *Thesis 1883*. Iowa State University Archives/Special Collections. In 1884, a year after the organization of the Domestic Economy program, Gertrude Wynn described how scientific domestic education came to the aid of modern housekeeping, saying, "Domestic Economy is but the systematic application of science to all the details of the housekeeper's duties, including the numerous and economical methods of using the materials of home comfort and increasing the sources whence home comfort is derived." She also viewed home science as a moral science, the best method of building character, promoting a desirable work ethic, and maintaining cleanliness in all aspects of the home. Wynn did include architecture, chemistry, and mechanics as vital areas of study for domestic women, but she did not describe the principles of these fields or how they might lead to new ideas. Wynn simply relied on the skills to optimize the efficiency of building and maintaining of the home. See Gertrude Wynn, "Home Science." *Theses 1885*. Iowa State University Archives/Special Collections.

M. Helen Coe noted, "The professions need not her assistance so much as the home life needs to be regulated and systematized. Long since mankind welcomed literature, music, and art to the home and these have elevated and transformed it to a place of beauty and culture. Science shall add system, health, and wider intelligence. The artist has painted the ideal home; the musician sung of it, the poet praised it: it remains for the

Since initial organization of the Iowa Agricultural College curriculum in 1867 and the establishment of specialized civil and mechanical engineering studies in 1870, no greater amount of change had taken place for non-agricultural students than during the 1880s. Students recalled how Bassett “remodeled the course of study in the mechanical engineering department to bring it up to the standard of the leading eastern institutions,” and how he brought “forward the practical side of engineering.”⁸⁶ However, while the students may have seen the changes as modern and beneficial, Bassett had completely reordered the system of education for engineering and science students, consequently undermining the liberal education of students in the process. The earlier basis of the college’s curriculum included technical as well as liberal education for all students. Its motto on the cover of every course catalogue was “Science with Practice”⁸⁷, but Bassett effectively did away with the science, and focused on the practice. On May 1, 1887, Bassett resigned from the college, though the reasons remained unclear, even in published board minutes.⁸⁸

Charles Scribner, a graduate of Princeton and the Stevens Institute, arrived in the spring of 1888 to replace Bassett and consequently eliminated the Worcester Method of production that Bassett had employed. Scribner instead reintroduced the theory with practice methods that had been utilized under Welch’s administration. Scribner allowed students to continue their practical application studies, but required them to demonstrate more complete

scientist to prove the truths of which they dreamed.” See M. Helen Coe, “The New Science.” *Theses 1882*. Iowa State University Archives/Special Collections). Female students accepted their place in the home, however, they clung to the ideals of science and how it might improve their lives. The ideas promoted by Agatha West and Helen Coe epitomized the ideals of the Iowa Agricultural College new domestic economy program, while retaining the essence of Welch’s original college mission incorporating both theoretical learning and applied training.

⁸⁶ *History and Reminiscences of I.A.C.* (Des Moines: Press of The Geo. A. Miller Printing and Publishing Co., 1897), 221. Iowa State University Archives/Special Collections.

⁸⁷ *Iowa State College Course Catalogues, 1880-1890* (Ames: Published by the College, 1880-1890). Iowa State University Archives/Special Collections.

⁸⁸ *Iowa State College Course Catalogue, 1889* (Ames: Published by the College, 1889), 9. Iowa State University Archives/Special Collections.

calculations and analysis than found under Bassett's tenure.⁸⁹ Professor Scribner advocated a return to focusing on exercises for students, as opposed to manufacturing in the workshop. He understood that practical training still had a place within the overall education of the engineer, but insisted that students needed a solid foundation in theoretical principles. Scribner established a systematic curriculum based on a progression from concept and calculation exercises, to mechanical drawing, and finally workshop training. Students could explore additional concepts, such as construction and manufacturing, once they had finished supplementing their practical training with classroom instruction.⁹⁰

Scribner needed time to reinstitute classroom learning with the workshop experience and reorient Iowa Agricultural College's direction. For a time, he had to oversee many senior theses that still incorporated almost no scientific principles or mathematical analysis. While student thesis titles appeared similar to those under Bassett, many of the students who completed their work under Scribner nevertheless soon began including far more rigorous analysis. Men's work included complete designs for a Pratt truss bridge, steam boiler tests, and mechanical and economic analyses of the college trolley system. Women continued to focus on the medical profession, education, language, art, religion, and their work in the home, but in the sciences they began to incorporate more scientific principles than seen in the previous three years.

C.M. Canaday's 1887 thesis examined the location of railway lines utilizing geological and population considerations. Canaday noted predetermined weight limits that construction foremen needed to account for during the laying of the track. He also spent a

⁸⁹ Earle D. Ross, *A History of Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942). See also *Biennial Report of the Board of Trustees 1883-1886* (Des Moines: State Publisher, 1883-1886). Iowa State University Archives/Special Collections.

⁹⁰ *Thirteenth Biennial Report of the Iowa Agricultural College and Farm, 1888-1889* (Des Moines: G. H. Ragsdale, State Printer, 1889), 35-36. Iowa State University Archives/Special Collections.

considerable amount of space in the thesis on how population centers influenced the direction and utility of various railway lines crossing the state of Iowa and neighboring regions.

Canaday did not perform any calculations himself, nor did he attempt to analyze railway and population location in any kind of statistical fashion.⁹¹

Within a year, Scribner did begin to implement more stringent demands for student theses. Clarence Baker created a complete set of designs for a Pratt truss bridge in 1888, including the necessary construction blueprints and calculations for stress, material strength, and geometric loading that the bridge would undergo during its lifetime. Based mostly on table values and algebraic calculations, Baker's treatment of bridge construction surpassed the methods utilized by Bassett's students just three years earlier.⁹² Baker's detailed experience with bridge design led immediately to a job as a bridge engineer in Des Moines, Iowa.⁹³ While Bassett's students described construction techniques in their theses, Scribner's students not only demonstrated they knew how to build the bridge; they could also design a bridge for specific locations and uses.

Analysis of student work between the latter 1870s and 1890 provides information about what students learned in the classroom and how they applied that knowledge to their practical education. Students concentrated on mastering the underlying principles of science and engineering during the years when faculty stressed those ideas. However, student writings also demonstrated how the opposite emphasis on practical education influenced their learning experience and future job outlook, as seen in the mid- and latter 1880s. Many of the men who obtained workshop training at Iowa Agricultural College between 1883 and 1887

⁹¹ C. M. Canaday, "Railway Location." *Theses 1887*. Iowa State University Archives/Special Collections.

⁹² Clarence Baker, "A Complete Design for a Pratt Truss Bridge." *Theses 1888*. Iowa State University Archives/Special Collections.

⁹³ Wheeler, "History of I.A.C. Alumni." *Aurora*, Vol. 20 (July 1891): 27. Iowa State University Archives/Special Collections.

went on to work as day laborers or returned to the farm, rather than attaining more ambitious or prestigious employment. Students before 1883 and after 1887, by contrast, often gained enough training to become foremen, entrepreneurs, or even college professors. According to alumni news reports, almost no one attained such status who had graduated during the mid 1880s, during Bassett's teaching tenure. Throughout this entire period, most women married and became housewives and mothers, regardless of the type of training they received. A steady number of women went into teaching full time each year. Significantly, those few women who became school principals were those who had graduated prior to 1883 and after 1888.⁹⁴

⁹⁴ Wheeler, "History of I.A.C. Alumni." *Aurora*, Vol. 20 (July 1891): 23-28. Iowa State University Archives/Special Collections. See also *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 339-367.

Women also demonstrated increased proficiency in scientific principles and their applications under Scribner's tutelage. They had even begun to re-enter the physics laboratory by 1890, after almost a ten year absence. See *Iowa State Student*, 27 August 1890: 1. Iowa State University Archives/Special Collections. Editors remarked that three female students had enrolled in the physics course and laboratory during the spring term. However, even with the wider access to classroom learning in the sciences, female students approached their studies in a fashion distinctly different from the period before 1883. Rhetoric about woman's place as helper, housekeeper, and child care provider, as well as moral protector of society, pervaded their work.

Lizzie McCuskey, an 1888 graduate who became a school teacher, wrote about women's role in the medical profession and commented, "Tenderness, sympathy, patience are the characteristics of a true physician. Not skill in science alone, but the wisdom and love taught by the Divine Healer marked the hand that carries with it the greatest power for healing. Is not woman by nature fitted for this work?" See Lizzie McCuskey, "Women in the Medical Profession." *Theses 1888*. Iowa State University Archives/Special Collections. Female students like McCuskey no longer viewed science as a valuable direction for learning in and of itself. They approached education and their experiences by interpreting science as a part of their gendered sphere. Laura Moulton spoke about elementary level education in her 1888 thesis. Her argument defined women as helpers to men at home and in society and noted female skill at performing tasks many tasks in the home and in the schoolroom. She said, "The Average American girl needs an education that is a usable one that equips her for helpful service in the world.... I therefore plead for that lower [elementary] education which endows a girl with what our New England grandmothers called faculty, as distinguished from that which seeks to turn out accomplished ladies. Faculty is the knack of doing things as they ought to be done." Laura Moulton went on to teach in Red Oak, Iowa. See Laura R. Moulton, "The Lower Education." *Theses 1888*. Iowa State University Archives/Special Collections.

Some women broke away from the new norm and provided deeper analysis of intellectual matters, leading them to good jobs. In 1889, Mary Zimbelman investigated the historical development of differential and integral calculus. She also presented modern astronomical and engineering uses for higher mathematical concepts, demonstrating her advanced knowledge in a male dominated subject area. See Mary Zimbelman, "The Differential and Integral Calculus." *Theses 1889*. Iowa State University Archives/Special Collections. Her college experiences led directly to a long term high school teaching position. Minnie Roberts examined how society obtained and organized scientific knowledge in her 1890 thesis "The Means and Basis of Knowledge." She translated her undergraduate mathematical and scientific studies into a mathematics teaching position at

Most graduates of Iowa Agricultural College probably gave little thought to the long term importance of their educational experience. They found a job, returned to the farm, or went into business for themselves. An examination of the college alumni lists reveals only a very small handful of well known individuals, including Carrie Chapman-Catt and George Washington Carver.⁹⁵

The passage of the 1862 Morrill Act allowed institutions across the nation to develop applicable and innovative techniques of instruction for working-class citizens. At Iowa Agricultural College, one of the largest early land-grant schools, administrators and professors incorporated various methods of theoretical and practical education during the opening decades. Professors under the college's first administration focused on developing well-trained and well-rounded students. They placed a balanced emphasis on theoretical principles and practical training. Students demonstrated this balance of knowledge and skill by producing senior theses incorporating detailed analyses and laboratory work. In the mid 1880s, administrative changes resulted in the hiring of professors interested in developing workers for the manufacturing trades and industrial businesses. After the elimination of theoretical coursework in favor of shop training and production, many students exhibited a complete lack of understanding in scientific principles. After 1888, new administrators and professors worked to implement a more even-handed approach to coursework, integrating

Iowa Agricultural College the following year. See Wheeler, "History of I.A.C. Alumni." Aurora, Vol. 20 (July 1891): 23-28. Iowa State University Archives/Special Collections.

McCuskey's and Moulton's words demonstrate how Iowa Agricultural College women's approaches to education after 1883 typically incorporated a supposedly feminine and innate sense of sympathy and empathy, along with declarations about women's place as helpers in society. After 1883, most female students approached the sciences almost exclusively as a justification and tool for their work in the home. Zimbelman and Roberts, by contrast, followed a pattern more typical of women who studied the sciences prior to 1883, including Ellen Rice and Ida Twitchell. These women approached the sciences in a manner similar to men, which required them to learn the underlying principles and various applications.

⁹⁵ *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897): 345, 363. Carrie (Lane) Chapman-Catt graduate in 1880 and went on to become a well known lecturer and leader in the women's suffrage movement. George Washington Carver graduated in 1894 and became the Professor of Agriculture at the Tuskegee Institute in Tuskegee, Alabama.

theoretical principles back into the practical training their students had already received.

Though not as technically adept as many of their predecessors, students graduating after 1888 did demonstrate a more complete mastery of their chosen field.

The combination of overall industrial growth and national, rather than local or regional, expectations for professional engineers had a significant impact on the organization and curriculum of Iowa Agricultural College after 1890. As agricultural and non-agricultural industries were established and expanded in smaller communities across the state, they required an ever increasing supply of skilled workers who had the necessary training in civil or mechanical engineering. Over time, many of those independent local businesses allied with, or became subsidiaries of national companies. By the late 1880s, the college administration and faculty in Ames realized that their institution could fulfill this need, if they made the necessary changes in curriculum, hired faculty with knowledge of the national expectations for engineering graduates, and funded the improvement of the college's science facilities.⁹⁶

While faculty and students at the Agricultural College went through almost a decade of trial and error experiences, Iowa's industrial development after 1880 took place at a fairly even pace and across a wide spectrum of business opportunities and regions. Though agriculture remained the largest single industry, many others contributed to the economic improvement of the state. Iowans continued to expand the lumber industry along the Mississippi River, leading to that industry's peak in 1892. Iron and steel production, railroad repair and construction, chemical production, and farm implement manufacturing became

⁹⁶ Dorothy Schwieder, *Iowa, The Middle Land* (Ames: Iowa State University Press, 1996), 250-251. Schwieder gives descriptions of the Maytag Company and the Younker's Brother's Department Store as two examples of local businesses that became national entities.

increasingly important economic ventures from the mid-1880s until after 1900.⁹⁷

These industrial developments did not go unnoticed by administration and faculty in Ames. The importance of trained engineers to the design and construction of bridges, steam engines, roads, and agricultural tools became increasingly obvious to those charged with providing Iowa with an advanced workforce. Using the statistics of the classes of 1887 and 1889, President Chamberlain stressed the importance of industrial pursuits to the Board of Trustees. Sixteen students went into agricultural and horticultural jobs, while 24 entered professions in civil, electrical, and mechanical engineering, architecture, design and draughting, and industrial chemistry. These numbers supported his claim that the college was providing a broad spectrum of educational opportunities and that the workforce of Iowa needed to adequately fill the professional roles needed in agricultural and industrial endeavors.⁹⁸

Within his 1889 report to the Trustees, President Chamberlain emphatically changed the focus and purpose of Iowa's land-grant college from simply practical to scientific and professional. Chamberlain stated that public assumptions regarding the college's purpose "hurt us with the farmers.... and with those who desire other technological and scientific instruction." Farmers saw only "instruction in agricultural labor, to teach mere farm processes, ordinary hand-work, requiring merely knack and practice. The others say as you teach only agriculture, we will go elsewhere." Chamberlain proclaimed that to properly fulfill the mission of the college, as laid out by the Morrill Act and the related 1884 state legislation, the college had to move beyond the simple processes in agriculture and the mechanic arts.

⁹⁷ Dorothy Schwieder, *Iowa, The Middle Land* (Ames: Iowa State University Press, 1996), 236-237, 240, 250-251. Schwieder gives a broad, general survey of manufacturing concerns in Iowa between 1870 and 1940.

⁹⁸ *Thirteenth Biennial Report of the Iowa State Agricultural College and Farm, 1888 and 1889* (Des Moines: G.H. Ragsdale, State Printer, 1889), 10. Iowa State University Archives/Special Collections.

While students could learn these skills better and more cheaply in a shop or on a farm, the college environment was meant for teaching the “related science, underlying principles, and processes too intricate or difficult for the unskilled, uneducated laborer.”⁹⁹

Chamberlain purposefully went about hiring faculty that mirrored his vision of the college’s broad educational mission. When Charles Scribner took over in June 1888, he took a cautious approach to reorganizing the mechanical engineering department so that it balanced theoretical instruction with practical training. He praised his predecessors for leaving the shop in an “improved state.” But he also noted that a great deal of work still needed done, and “the whole course of instruction needed revision.” Scribner followed a carefully planned system of instruction and practical work. The principles taught had been systemized and the materials calculated to embody those principles. The trial and error methods employed by professors under Welch and his followers had seen their final days. The new professors came equipped with plans, systems, and a body of literature created by the increasingly professionalized engineering disciplines. But that did not mean that practical, hands-on training that applied to the needs of Iowa industries did not remain important. Scribner allocated a great deal of space in his biennial reports to the organization of the shops, need for and uses of instructional tools and machinery, and the advancements of other institutional engineering programs, such as the introduction of electrical and railway engineering courses at Wisconsin.¹⁰⁰

Although the college successfully navigated a transition to more professionalized instruction under Chamberlain’s administration, his relationship with the general public

⁹⁹ *Thirteenth Biennial Report of the Iowa State Agricultural College and Farm, 1888 and 1889* (Des Moines: G.H. Ragsdale, State Printer, 1889); 7-8. Iowa State University Archives/Special Collections.

¹⁰⁰ *Thirteenth Biennial Report of the Iowa State Agricultural College and Farm, 1888 and 1889* (Des Moines: G.H. Ragsdale, State Printer, 1889); 35-39. Iowa State University Archives/Special Collections.

suffered. His constant references to experiences on his Ohio farm aggravated Iowa farmers and student riots and rebellions over fraternity activities put Chamberlain in an impossible situation with the college faculty and students. In a letter to Professor Stanton in 1920, Chamberlain admitted to his colleague that while his efforts were “sincere, honest and industrious, I think I was not exactly adapted.” Chamberlain retired in 1890, followed soon after by the resignation eight professors. Most notably absent the following year were Loren Smith as the professor of agriculture, after he heard the board no longer supported him, and civil engineering professor and alum Charles Mount left for a job at the Brown Hoisting and Conveying Machine Company in Cleveland, Ohio.¹⁰¹

Though public discontent in late 1890, organized by Henry Wallace through his editorship of the *Homestead* journal, focused on agricultural education at the college, most critics admitted that the curriculum and work performed in engineering and veterinary medicine in Ames was admirable and of high quality. But the public expressed a growing desire for the “Iowa farmers’ institution” to be “managed by Iowa men, imbued with the spirit of progress in this state.” William Beardshear, then head of the West Des Moines school district, accepted the presidency of the college on a platform of agricultural education reform and as a mediator between public and institutional factions over systems of education.¹⁰²

Though his efforts to stabilize the agricultural department, curriculum, and experiment station took most of the 1890s, Beardshear had more immediate success with the other technical fields. He focused on hiring faculty who brought modern leadership and nationally accepted systems of instruction to the college, and he especially desired loyal and cooperative

¹⁰¹ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 112-113. Information on the later employment of professors was detailed by students in their 1897 collection on the college and staff. See *History and Reminiscences of I.A.C.* (Des Moines: the Geo. A. Miller Printing and Publishing Co., 1897), 221.

¹⁰² Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 197-199.

personnel. In 1891, he hired George Bissell and William Meeker in mechanical engineering, Anson Marston in civil engineering, William Franklin in electrical engineering and S.W. Beyer in mining engineering. By 1892, Bissell, Marston, and Franklin were all made heads of their respective departments and a period of stability, modernization, and expansion began for all the engineering programs at Iowa.¹⁰³

Concurrent with the changes in administration and faculty between 1888 and 1892, came a significant growth in engineering enrollment. In 1889, Charles Scribner tallied thirty-three students taking engineering coursework, freshmen to seniors. Just two years later, that number had more than doubled to seventy-eight. Scribner attributed this growth to the popularity of the just inaugurated electrical engineering program, the growing needs of the department to meet broad requirements for all the engineering and science fields, and the knowledge that graduates obtained highly desirable positions and commanded quality salaries. Marston and the rest of the engineering faculty continued to see dramatic increases in the numbers of engineering students through the rest of the 1890s, reaching 81 graduates in mechanical engineering, 74 in civil engineering, 21 in mining engineering, and 164 in electrical engineering by 1900. This compared favorably to the number of degrees in agriculture which remained steady at 154 total graduates between 1888 and 1900.¹⁰⁴

¹⁰³ Earle D. Ross, *A History of the Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 205-207. For a more impressionistic account of the faculty see *History and Reminiscences of I.A.C.* (Des Moines: the Geo. A. Miller Printing and Publishing Co., 1897), 221-254.

¹⁰⁴ *Fourteenth Biennial Report of the Iowa State Agricultural College and Farm, 1888 and 1889* (Des Moines: G.H. Ragsdale, State Printer, 1891); 32-33. Iowa State University Archives/Special Collections. In their departmental surveys in the *Biennial Reports*, Marston, Bissell, and Franklin routinely noted the growing number of students that necessitated more funding for equipment, building space, and library materials. With an apparent nod to the politics of acquiring funding, they kept their request fairly basic and generalized before 1895, stating simply that numbers of student increased and the methods of instruction were improving, so they needed more basic equipment. The total numbers of graduates and degrees granted began appearing in the *Report of the Commissioner of Education* in 1870. The numbers quoted were obtained or calculated from a survey of the yearly publications between 1887 and 1900. See *The Report of the Commissioner of Education Made to the Secretary of the Interior for the Years 1887-1900*, ed. John Eaton, Jr., N.H.R. Dawson, and W.T. White (Washington: Government Printing Office, 1887-1900).

The engineering programs also benefited from the completion of a dedicated building and steady allotments of funding through the 1880s and 1890s. President Welch had begun the procurement of funds in 1880 for an engineering building, with \$5,000 going towards the east wing in 1882 and \$7,500 used to complete the west wing in 1884. By the time Beardshear appointed a new coterie of engineering faculty in 1891, those departments had acquired over \$35,000 for equipment and building improvements. By 1895, the total inventory of the agricultural department only reached \$15,000, but considerably more had been spent on buildings, land improvement and livestock. The sharp disparity in departmental funding highlights not only the power of faculty leadership, but also the legislature's recognition of the importance of science and engineering to business and industry in the state during the early decades of organization at the Iowa Agricultural College.¹⁰⁵

By 1892, the pioneer era at Iowa Agricultural College had come to a close. The desire of administration and faculty to promote agricultural and industrial benefits of the college on focused state level began giving way to national philosophies and programs. The growing professionalization of the engineering fields arrived in the form of new professors, new systems, and technical advancements. The intellectual models of the East collided with the practical needs of the Midwest, combining practical skill, theoretical knowledge, and managerial experience. The move towards a national system of engineering education loomed on the near horizon.

¹⁰⁵ A brief summary of departmental growth and funding can be found in *History and Reminiscences of I.A.C.* (Des Moines: the Geo. A. Miller Printing and Publishing Co., 1897), 261-298. More detailed accounts of the actual funding acquired and equipment purchased or desired by faculty was presented in the *Biennial Reports*. See *Biennial Reports of the Iowa State Agricultural College and Farm, 1868-1900* (Des Moines: State Printer, 1868-1900). Iowa State University Archives/Special Collections. Professors began describing the available equipment and machinery that students might use as part of their practical instruction in the college catalogue beginning in 1890. See *Iowa Agricultural College Catalogue, 1891-1900* (Ames: Published by the College, 1891-1900). Iowa State University Archives/Special Collections.

CHAPTER 6.
***LITERIS DEDICATA ET OMNIBUS ARTIBUS* – ENGINEERING EDUCATION AT
 THE UNIVERSITY OF NEBRASKA BEFORE 1893¹**

Supporters of state sponsored higher education in Nebraska dealt with a culture similar to that of other Midwestern states and an environment distinctly different from its eastern neighbors. While the land-grant institutions of Michigan, Wisconsin, and Iowa grew and developed with the support of an established frontier population and economy, Nebraska's land-grant college existed on the true frontier of America in the 1870s. Nebraska settlers dealt with the new challenges of the prairie frontier, as opposed to the lands east of the Missouri river which received greater rainfall, possessed significant quantities of timber and minerals, and by the latter 1860s had already begun to see the growth of manufacturing and industry.

The first settlers in Nebraska were speculators, interested more in land acquisition and sale than in real farming. But this business necessitated transportation, which meant steamboats in the 1850s and railroads by the 1860s. Mechanics congregated in the Missouri River port towns, such as Nebraska City, Brownsville, Bellevue, and Omaha. The economic crisis of 1857 allowed many farmers to make their way into Nebraska to begin farming, and a rush of Civil War veterans came after 1865. Most of these farmers focused on corn and wheat crops, with cattle ranching taking over in the northern half of the state. Other service industries also flourished as the towns began popping up along rivers and railroad lines. Newspaper publishers flourished in every town, especially isolated ethnic communities.

¹ "Dedicated to Letters and to All the Arts." The University of Nebraska administration used this as the official motto from the opening of the institution.

Saloon owners and merchants also did good business as settlers flocked the region in droves from the east. And as the saloons grew, so did the brothels and number of prostitutes.²

While agriculture dominated state politics and economics, people also began engaging in other businesses. Surveyors trekked across the state plotting railroad routes, townships, and acreages for speculators and farmers alike. By the 1860s, the first rail lines had reached Cozad, in western Nebraska. Engineers arrived in western Iowa and in the port towns of Nebraska to oversee the construction of steamboat docks, roadways, and to help in designing the first buildings in Omaha, the largest of the port cities. But manufacturing and industry struggled to find a market of any kind, and the steamboat businesses essentially collapsed by the late 1860s as the railroads continued to push east.³

Early settlers in Omaha and Nebraska City focused on agricultural support businesses, such as banks, land offices, and implement dealerships, along with the manufacture of consumer goods like shoes and farm tools. Most of these industries in Nebraska employed fewer than 50 people, and remained little more than cottage industries. Manufacturers struggled to succeed and nearly all of the factories closed by the late 1860s, since it was easier to ship in finished goods from the east than ship in raw materials. Territorial politicians promoted the region's coal, copper, granite, and salt deposits, but industry required a greater variety of raw materials, and Nebraska simply didn't have them. Businessmen quickly realized that agricultural processing industries were the only profitable ventures. Politicians encouraged settlers to plant trees, and by the mid-1860s, the leading industry, outside of agriculture, was sawmilling, which employed about 155 people total in the state of Nebraska.

² Dorothy W. Creigh, *Nebraska, A Bicentennial History* (New York: W.W. Norton & Company, 1977), 62-71, 108-111.

³ Dorothy W. Creigh, *Nebraska, A Bicentennial History* (New York: W.W. Norton & Company, 1977), 62-71.

Other settlers built successful businesses in gristmills, flourmills, and stockyard management. The settlers in Nebraska remained firmly associated with the working classes, but early leaders placed a fundamental importance on establishing and improving public education.⁴

Nebraska became a state in 1867, five years after the passage of the first Morrill Act. However, politically savvy legislators who wanted to boost the stature, and population, of the new state capital city of Lincoln used the promises of culture, economic stimulus, and intellectual prestige associated with higher education to their advantage, along with the funding of the Morrill Act. Just as in other states, political quarrelling, issues of practicality and public jealousy over the site of the new institution hindered educators' early efforts to improve the college. However, political and institutional momentum provided supporters with the necessary time and space to prevail.⁵

Building upon the organizational trial and errors of other Midwestern politicians and their state land-grant colleges, University supporters and politicians passed "An Act to Establish the University of Nebraska" in 1869, just two years after the state government and capital city had been established. Michigan supporters had had few, if any, models to guide the organization of their Agricultural College in East Lansing. Wisconsin officials attempted to marry their classically oriented state college in Madison with the guidelines of the 1862 Morrill Act. And Iowa's Agricultural College administrators in Ames slavishly followed the strictures of the Morrill Act to separate themselves from the classical University in Iowa City. Nebraska administrators took note of what others had learned and experienced, structuring the

⁴ James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 94-97, 103-116.

⁵ James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 150. The tangled intricacies of the 1862 Morrill Act and early Nebraska politics are analyzed in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 6-11.

college organization and providing curricula that met the requirements of a full-fledged land-grant institution while also allowing for a wide array of classical studies.⁶

Organizers specifically used the 1862 Morrill Act to fund and guide the curricular organization of the University. They created six colleges; a college of ancient and modern literature, mathematics, and the natural sciences, a college of agriculture, a college of law, a college of medicine, a college of practical science, civil engineering and mechanics (designated the industrial college), and a college of the fine arts. University organizers provided the industrial college with department chairs of mathematics, chemistry, natural philosophy, surveying and navigation, geology and mineralogy, engineering construction, architectural construction, drawing and the arts of design, geography and mapping, astronomy, comparative anatomy, metallurgy, and practical experiment in properties of materials. The organizers clearly wanted to address all educational areas immediately, in order to promote a “full and complete institution of higher learning.” Most other land-grant and technical universities did not provide this level of specialization until well into the 1880s and 1890s. However, while the University had the positions specifically provided for before the school opened, it took several decades for University faculty to fully realize the complete list of programs.⁷

By the early spring of 1871, the Board of Regents had installed the first faculty members and construction of the first building was complete. Allen Benton, the first Chancellor of the University of Nebraska, was an ordained minister in the Christian Church, a scholar in ancient languages, and before coming to Nebraska was the president of

⁶ *An Act To Establish the University of Nebraska*. RC 01/01/06, Box 1, Folder 1: 320-321. University Archives / Special Collections – University of Nebraska-Lincoln.

⁷ *An Act To Establish the University of Nebraska*. RC 01/01/06, Box 1, Folder 1: 314-316. University Archives / Special Collections – University of Nebraska-Lincoln.

Northwestern Christian University (now Butler University) in Indiana. Samuel Aughey, a Lutheran Pastor from Omaha, took charge of the chemistry and natural science courses. The Board promised to hire a professor of mathematics before classes started in September. The first faculty represented traditional values and accepted methods of liberal arts education. George E. Howard, an early University graduate and professor, wrote that the early faculty were “not men of wide national repute...not one was of transcendent ability. Most of them were persons of strong character and high ideals. The dominant conservatism of the group was a real safeguard in undertaking the then bold experiment of determining the methods, planning the curriculum and starting the traditions of a secular, a public university for a pioneer society.” At least this one early graduate clearly had a low academic opinion of their professors, but recognized that the work of organizing and running the early University took a great deal of compromise and cultural awareness.⁸

Benton offered a much broader and all encompassing vision of the University’s mission in his inaugural address. He stated that America’s colleges and universities had “one animating spirit – to fit man for his real life-work.” He pointed out that the professional schools for medicine, law, and teaching had found a balance between intellectual studies and practical education. Now, the industrial classes across the nation demanded higher education that fit them for professional endeavors, and he aimed to meet those demands by utilizing the 1862 Morrill Act funding and mandate for “agricultural and mechanic arts” training. However, while Benton opened his address with grand visions of education that met everyone’s needs and highlighted the practical education demanded by farmers and

⁸ Howard is quoted in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 23.

mechanics, his message quickly returned to the moral attributes of university instruction and the politics of funding and administering the University.⁹

Students at the University entered a system firmly based in classical instruction. The Board provided a Latin school to prepare students for collegiate work, and provided a detailed outline of the Classical Course in the first announcement of courses in 1871. Freshmen took geometry, Latin, Greek, Greek history, English, Trigonometry, and Botany. Sophomores had classes in surveying and navigation, Greek, chemistry, English, Latin, Medieval and modern history. Juniors had Latin, Physics, calculus, French or German, and Astronomy. Seniors took intellectual philosophy, geology, zoology, French, German, or Greek, moral philosophy and Christian Evidences, history of civilization, physical science, constitutional law, political economy, and logic. Those students in the Scientific Course took the same courses as those in the Classical Course. Administrators only made an allowance that scientific students didn't have to take Latin or Greek. The combination of religiously trained faculty and a classically oriented curriculum severely hampered the early establishment and progress of engineering and technical studies, despite the organizers' reliance on the language of the 1862 Morrill Act.¹⁰

⁹ Allen R. Benton, "Address." *Address at the Inauguration of Allen R. Benton, As Chancellor of the University of Nebraska, 6 September 1871* (Lincoln: Statesman Power Press Job Print, 1871), 8-10. RG 00/05/00 University General Commencements 1871-1890, Box 1, Folder 1. University Archives / Special Collections – University of Nebraska-Lincoln. In fact, many of the early addresses proclaimed the foresight of the University administration in its slow growth and emphasis on "excellent educational values" which encompassed all areas of instruction. For instance, see James Woolworth, "The Duty of the State to provide higher instruction." *An address delivered before the University of Nebraska at its first annual commencement, 26 June 1872* (Lincoln: by Order of the Regents, 1872), 3-30. RG 00/05/00 University General, Commencements, Box 1, Folder 3; and L. Crounse, "*Quanti Est Sapere!*" *An Address Delivered Before the University of Nebraska, at its second annual commencement, 24 June 1873* (Lincoln: by Order of the Regents, 1873), 3-20. RG 00/05/00 University General, Commencements, Box 1, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

¹⁰ "Courses of Study." *Announcements of the University of Nebraska, 1871-72* (Lincoln: State Printer, 1871), 8-11. RG 0/3 General Histories, Box 1, Folder 1. University Archives / Special Collections – University of Nebraska-Lincoln.

Several factors limited the growth and success of science and technical instruction during the early years of the University. First, citizens dealt with repeated drought, insect swarms, and economic depressions in the 1870s and 1880s. Second, board members, administrators, and faculty had largely been educated in the traditional classical system and maintained strong ties to the local churches as sources of organizational structure for widely separated communities. As a result, the necessary leadership versed in scientific knowledge and technical skill did not exist as a part of the early University system. Third, unlike many other agricultural and land-grant colleges, administrators in Nebraska did not utilize a manual labor system in which students helped construct buildings, build a model farm, or produce tools and machinery which could then be used by future University shops and farm operations. This followed directly from the fact that early instructors showed no interest in such work and administrators demonstrated no interest in bringing such talent to the university.¹¹

Despite the lack of scientific and technical emphasis in the early curriculum, Samuel Aughey, the professor of natural sciences, made one of the most significant and positive impressions on early college students and the public. University public relations officers noted that a historian wrote that Aughey's "hold on the people of the State for many years was great, and as he was constantly mingling with them, he did much to give strength to the University by making it known to the people." Aughey also became the state chemist, along with his instructing duties. He repeatedly noted that the requests for chemical work were so

¹¹ The early faults and failures of the University are commonly discussed in University histories, addresses, and memoirs. For instance, see "U. of N. Chartered Eighty Years Ago." *Sunday Journal and Star – Feature Section* 13 February 1949: 1D-7D. University Archives / Special Collections – University of Nebraska-Lincoln; Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University 1869-1919* (Lincoln: University of Nebraska Press, 1969), 22-32; and Robert E. Knoll, *Prairie University, A History of the University of Nebraska* (Lincoln: The University of Nebraska Press, 1995), 7-9.

great that he had to make judgment calls on what he thought was the most important to the public. His work for the state included chemical analysis of soil, clay, shale, well water, and sugar beets. He also provided quantitative analyses “of thirteen varieties of liquor from Lincoln for the Lincoln Temperance Society, the stomach of Mrs. Burnham for Cass County Commissioners, Mrs. Winslow’s soothing syrup for Dr. Hurlbut, Lincoln, and of old Bourbon for James Sullivan.” Aughey provided Lincoln and the surrounding region with technical expertise and authoritative scientific leadership; a modern day forensic expert.¹²

Aughey himself provided recollections that science did hold a place of intellectual importance at the early University. In an 1881 address, he noted that the educational philosophy of the early administration and staff rested on “scientific spirit.” By this, he meant that “scientific methods are applicable to all studies.” He wanted students in literature and languages, political economy, and physics to all make inductions from facts they gathered from nature, consciousness, language, people, and the developing world around them. He asked them to use their senses, their intuition, and processes of reasoning in everything they did. Not only did Aughey believe that the scientific method permeated every aspect of education, he believed that it was the pre-eminent “spirit of the epoch.” He noted that it was “revolutionizing the times” by “building the railroads, bridges, telegraph lines, uniting society by the telephone, and turning darkness into light by electricity.” Aughey highlighted those

¹² “A Sketch of Circumstances and Events Leading to the Chartering on February 15, 1869 of The University of Nebraska and a Report on Phases of the Early Life of the Institution.” Prepared by the University of Nebraska Department of Public Relations, 1920. RG 0/3, Box 1, Folder 4: 7. University Archives / Special Collections – University of Nebraska-Lincoln.

technological improvements that benefited the people of Nebraska, as well as declaring that the structured processes of thinking played into every aspect of intellectual thought.¹³

In an 1881 address, Aughey also recounted his first meeting with Chancellor Benton, in which Benton did emphasize the teaching and practice of science. Benton wanted Aughey to select a room that he could use as a lecture hall, work space, and demonstration laboratory. Both men voiced their regret that the organizers had not provided room for laboratories in their planning of the first building, University Hall. Whether Benton's first meeting with Aughey was sincere, or he simply played the good administrator welcoming his only scientist to campus is unknown. But Aughey lamented in his 1881 address, that after nearly ten years, the temporary laboratory arrangements they had settled on in 1872 had remained unchanged. The administration's and faculty's predilection towards classical education remained firmly in place.¹⁴

Another indication of how strong the classical style of education remained in the early years came from one of the first graduates, H.H. Wilson, who became one of the first judges in Nebraska. Judge Wilson entered the University in the fall of 1873 and graduated in 1878. He completed the preparatory Latin course and then graduated from the Latin Scientific course where he substituted modern languages for Greek. He recalled later that he completed the six year course in only five years because "instruction was by the textbook method." Wilson could teach at another nearby school while reading all of the assigned books, and then

¹³ Samuel Aughey, *The Ideas and The Men that Created the University of Nebraska, an address delivered before the University of Nebraska on Charter Day, 15 February 1881* (Lincoln: Journal Company, State Printer, 1881), 7-8. RG 00/14/00, Box 1, Folder 2. University Archives / Special Collections – University of Nebraska-Lincoln.

¹⁴ Samuel Aughey, *The Ideas and The Men that Created the University of Nebraska, an address delivered before the University of Nebraska on Charter Day, 15 February 1881* (Lincoln: Journal Company, State Printer, 1881), 15. RG 00/14/00, Box 1, Folder 2. University Archives / Special Collections – University of Nebraska-Lincoln.

simply take the exams when he came back to campus. He remembered that even chemistry consisted mostly of reading from the book. In 1878, Wilson's final year, George Woodbury, a graduate of Harvard University and professor of rhetoric, English literature, and history, introduced the library method, where students had to perform significantly more research and writing in their coursework. A few years later, George Howard, an early graduate and later history professor at the University, returned from a German University and further expanded the research method of instruction.¹⁵

Students who had an interest in practical engineering had a long wait at the University. Henry Hitchcock, the professor of mathematics brought from Knox College in 1875, included a semester of surveying in his mathematics curriculum, but no other shop work, design, or mechanical instruction existed within the curriculum before the 1880s. Aughey and Hitchcock did build up the chemical laboratory supplies and classroom demonstration equipment for the science departments beginning the first years, but physics and mechanic arts were left wanting. Benton requested a complete set of models from the U.S. patent office for illustrating machine design and use. The Patent Office allowed any interested institution to request models of any machines submitted to them, allowing colleges and universities to expose a larger portion of society to the mechanical innovations that might benefit their particular industries. It was basically a way for the patent office to advertise inventions on behalf of the men who submitted ideas. In 1873, Hitchcock requested more funding to purchase chemicals and recommended that the University purchase an Atwood's machine, a board with a series of pulleys and spring loaded force meters, to demonstrate the principles of

¹⁵ "H.H. Wilson Watched University Develop." *The Nebraska Alumnus* (December, 1926): 486. University Archives / Special Collections – University of Nebraska-Lincoln. George Howard Graduated in 1875 and became an instructor at the University in 1879. He was listed as a full professor in 1880.

falling bodies and a “frictional electrical machine” (today called a Van DeGraff Generator), both for the physics department. He also asked that a tutor be hired to assist Aughey in the chemistry department since his duties as an instructor and state chemist limited his effectiveness. While the administration did limit the expansion of science through the curriculum and physical space allotted to those areas, they did allow the faculty to slowly build up their instructional tools.¹⁶

The lack of agricultural and industrial education during the first classes did not go unnoticed. Uriah Bruner, a judge from West Point, Nebraska, headed the committee which investigated the requirements of 1862 Morrill Act and agricultural education. He addressed the Board of Regents in December of 1873, during the second year of classes at the University, to essentially scold the Board and administration for not properly allocating funds and resources to educating farmers and mechanics. He also reported that during his attendance at the National Education Convention in Elmira, New York, delegates stated that agricultural colleges were almost entirely failures. He specifically noted that students in Massachusetts, New York, and New Jersey who took the agricultural course did return to farming, and those schools had enormous budgets. He implored the Regents in Nebraska to think carefully about how an agricultural and industrial school should be structured so that the students did return to the fields and shops in support of the state, especially in Nebraska, where agriculture dominated the economy and industry had yet to prosper beyond the expansion of railroads. Bruner noted that “our methods of instruction are defective and

¹⁶ “Course of Study Described.” *The Bulletins and Catalogues of the University of Nebraska, Lincoln* (Lincoln: Randall & Smails, Book and Job Printers, 1873), 12, 16-17. RG 00/07 Bulletins and Catalogues, Box 1, Folder 2; and H. Hitchcock and O. Drake, “Faculty Report to the Board of Regents.” Handwritten letter dated June, 1873. RG 01/01/01, Box 1, Folder 10. University Archives / Special Collections – University of Nebraska-Lincoln.

radically wrong.” He requested more scientifically trained faculty members, a working model farm on which to train the students, and laboratories and shops in which to train the mechanics. The reading and lecture methods that kept students in the classroom had to be “dispensed with immediately,” since they did not offer the appropriate instruction for the working class citizens of the state.¹⁷

Bruner’s chastisement worked. In 1874, S. R. Thomson, a local farmer of some renown, returned from a tour of eastern agricultural colleges to head Nebraska’s agricultural college and teach theoretical and practical agriculture. While students in the Scientific Course continued with only limited training in surveying, the faculty of the Agricultural College opened up more opportunities for practical training. Students focused primarily on farming related topics; meteorology, vegetable physiology (botany), anatomy and physiology of domestic animals, stock breeding, arboriculture, horticulture, landscape gardening, farm economy, and labor. However, they also had courses in mechanical physics and enough mathematics courses to understand basic engineering principles. Sophomores took field surveying, and juniors had at least one course in mechanical physics and machine design as they related to farm machinery, farm work, irrigation, and road, building, and bridge construction.¹⁸

Thomson’s success with the agricultural college was short lived. Student attendance dropped from fifteen to thirteen students between 1874 and 1875, Thomson’s first two years. He had wanted an experimental farm to extend the research and practical knowledge which

¹⁷ Uriah Bruner, “Address to the Board of Regents.” Handwritten document dated Dec. 16, 1873 meeting. RG 01/01/01, Box 1, Folder 8. University Archives / Special Collections – University of Nebraska-Lincoln.

¹⁸ “Agricultural College.” *The Bulletins and Catalogues of the University of Nebraska, Lincoln, Third Session, 1873-4* (Lincoln: Journal Company, State Printers, 1874), 28-33. RG 00/07, Bulletins and Catalogues Microfilm, Roll #1. University Archives / Special Collections – University of Nebraska-Lincoln.

farmers could quickly apply. The Board rejected the experimental farm approach and opted for a simpler model farm, where farming techniques were practiced and put on display. In the summer of 1875, donated animals died or had to be destroyed, and a locust swarm destroyed the model farm crops. The Board ordered the agricultural college students and faculty to begin planting trees on the University campus, rather than working the fields, and then sold the land to pay for a new dormitory. By September, Thomsen had seen the writing on the wall and offered his resignation. In December, the Regents accepted the resignation and began looking for a new director for the farm.¹⁹

This early episode clearly indicated the Board's desire to keep the University curriculum set in traditional methods. These men had no experience with technical education, and they saw a small population of farmers and city dwellers, neither of which seemed all that interested in building up industry or manufacturing businesses. They dismissed the practical value of the agricultural college and, despite repeated attempts by Chancellor Benton to acquire funding for engineering faculty and their courses, the Board ignored anything to do with practical or technical training in the mechanic arts. The Board also had a nearly empty state treasury to work with, even though the 1862 Morrill Act provided 500,000 acres of land and the 1864 Morrill Act amendment increased this amount by over one million acres. Legislators and Board members poorly managed the funds and their indifference and opposition to the industrial college limited the agricultural and mechanic arts courses for University students in the 1870s.²⁰

¹⁹ Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 39.

²⁰ The actual number of acres allotted under the 1862 Morrill Act varies across publications. Documents from the 1870s mention numbers in the hundreds of thousands. Publications in the 1890s quote 72 sections of land (46,080 acres) with an addition 90,000 for the Industrial College. However, larger amounts accrued between the

Continuing low enrollment and a brewing battle between supporters of traditional education and those who wanted more scientific coursework became a serious concern for Benton by the summer of 1875. In many other states, including Michigan and Iowa, narrow-gauge instruction referred to classroom and textbook instruction with limited or no practical training. In Nebraska, “narrow-gauge” instruction took the form of religious education as opposed to scientific training. Despite arriving in Nebraska with a strong traditional and religious educational background and supporting the technical aspirations of the land-grant college system, Benton drew criticism from both camps. In the spring of 1875, Benton wrote to his father in Indiana that he intended on leaving the following year, but by June he had already submitted his letter of resignation. He noted that “defective construction of the building, the impoverished conditions of the country, and the large outlays made in the opening of the University,” had all been very embarrassing. However, he also noted that under his guidance, the University had organized all the requisite classes, hired the necessary faculty, graduated ten students, and reached an annual attendance of over 150 students. For all his successes and failures, the University had only managed to implement half of the Morrill Act’s mandate, however. Prospective engineering students still awaited an appropriate curriculum and faculty to train them.²¹

federal grants and numerous state grants over time. The amount of land available under the Morrill Acts was usually mentioned in the *Annual Bulletins and Catalogues* during the 1870s. For instance, see Allen Benton, “Chancellor’s Report.” *Fourth Annual Bulletins and Catalogues of the University of Nebraska, Lincoln, 1874-75* (Lincoln: Journal Company, State Printers, 1875), 3-9. Later numbers were given in the *Nebraska State Journal Educational Souvenir, Lincoln Institutions of Learning, 1891*. RG 00/03 General Histories, Box 1, Folder 1. University Archives / Special Collections – University of Nebraska-Lincoln. Benton’s requests for engineering funding is briefly discussed in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 42.

²¹ The discussion of “narrow-gauge” and “broad-gauge” as defined by Nebraskans and Benton’s letter of resignation is quoted in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 48-53.

Edmund Fairfield arrived at in Lincoln in August of 1875. His training in theology led to a series of college presidencies and church pastorates between 1848 and 1875, primarily in Michigan and Ohio. Many University supporters thought Fairfield would bring harmony and balance to the curriculum and feuding educational factions. At the inauguration of Fairfield, S.J. Tuttle made a point to state that the law which provided the lands and funding for the University, the 1862 Morrill Act, required “great attention to those branches of learning related to agriculture and the mechanics arts.” In his inaugural address, Fairfield attempted to strike a balance between traditional studies and the necessity to incorporate more scientific curriculum into the modern University system. He noted that “the ideal university should provide for the highest possible attainments in every department. It is for universal culture, and not simply mental discipline.” He went on to state that along with other disciplines and departments “in civil engineering and mining, there must be opportunity for those who develop the great country with its boundless resources.” Administrators gave lip service to mechanic arts and engineering, but supporters had a great deal of opposition to overcome in a state rich with agricultural lands and poor in resources, industry, or a population vested with enough spare time to devote to higher learning. Family farmers just getting their farms up and running had little interest in sending their sons and daughters to the capital city for four years of classical or scientific instruction. They needed workers more than thinkers.²²

Nebraskans continued to see the dominance of agriculture in state politics and economics in the 1870s. Politicians established a Board of Immigration and State Board of

²² S. J. Tuttle, “Mr. Tuttle’s Address.” and Edmund Fairchild, “Chancellor’s Address.” *Inauguration of Edmund B. Fairchild, D.D., LL.D., As Chancellor of the University of Nebraska at Lincoln, Thursday, June 22, 1876*. RG 05/03/02 Office of the Chancellor, Edmund B. Fairfield, Box 1, Folder 2. University Archives / Special Collections – University of Nebraska-Lincoln. For an extensive discussion of Fairchild’s background and limitations as a college president, see Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 54-55.

Agriculture in 1870 to promote farm settlement, agriculture diversity, and to organize the State Fair as an annual exhibit of the state's agricultural and industrial progress. Railroad managers provided free transportation from eastern states, hoping that interested citizens and immigrants would travel to the frontier state. The population increased from 122,993 in 1870 to an estimated 250,000 in 1874. But most of these settlers remained firmly entrenched in farming and ranching. The great cattle drives of the 1870s often stopped at cities like North Platte, Cozad, Lexington, and for a time Grand Island. But the only profitable businesses for farming regions remained banking and general stores. Businessmen continued to rely on the railroad to bring in finished goods, rather than building factories in the sparsely populated plains regions. The public didn't require mechanics or engineers in any great numbers, and universities and colleges east of the Missouri River could supply more than the frontier railroads and factories needed. The slow progress of mechanic arts at the University tended to mirror the economic progress of the state.²³

The transition to a new chancellor in 1875 brought in new faculty, but no immediate improvements in mechanic arts, engineering, or other practical studies. Henry Hitchcock remained the only professor of mathematics and became the dean of college faculty. Samuel Aughey remained the only professor of natural science. The new administration and board did hire a new professor of chemistry and physics, Hiram Collier. Gilbert Bailey, a graduate of Nebraska was hired as an assistant professor in analytical and agricultural chemistry a year earlier. Harvey Culbertson, another University graduate, took over as superintendent of the farm and instructor in agricultural following Thomsen's resignation. Edgar Dudley, a first lieutenant straight out of the Military Academy at West Point, took charge of the newly

²³ James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 94-97, 186-198.

organized military science and tactics program. However, where other land-grant colleges might have had Dudley include some basic civil engineering instruction as part of the curriculum, at Nebraska, Dudley simply focused on marching drills and shooting exercises.²⁴

Chancellor Fairfield began making progress in the engineering and practical sciences curriculum in 1877, when he convinced the legislature to create a new Industrial College. In 1876, just five years after the University had opened, the Agricultural College did not really operate as a farm or instructional arm of the University and no engineering or mechanic arts college had been established. Fairfield and the Board proposed that the number of colleges authorized in the original charter be lowered to five instead of six. They wanted to combine the agricultural program with the sciences and engineering to form a larger applied sciences college which could operate separately from the more established traditional curriculum. Fairfield appointed Hitchcock in mathematics, Aughey in natural sciences, Collier in general chemistry and physics, Bailey in agricultural and analytical chemistry, Culbertson as superintendent of the farm, and Lieutenant Dudley in surveying and civil engineering. The contributing faculty to the new Industrial College suggests that the Board and Fairfield organized the new program to address concerns about the University not meeting the mandate of the 1862 Morrill Act. The administration and faculty specifically included a section labeled “Advantages” as part of the Industrial College description in the 1877 Catalogue,

²⁴ “University Faculty, Course of Study, and Agricultural College.” *Fifth Annual Bulletins and Catalogues of the University of Nebraska, Lincoln, October 1876* (Lincoln: Journal Company, State Printers, 1876), 7-32. RG 00/07, Bulletins and Catalogues, Box 1, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln.

noting that the “Industrial College offers to the sons of farmers or to any who desire to engage in industrial pursuits a first-class English [style] scientific and practical education.”²⁵

Fairchild’s creation of the Industrial College introduced a specific applied science curriculum to the University for the first time. Since Dudley was the only faculty member with any kind of engineering training, he was assigned the surveying and civil engineering courses, along with military instruction and tactics. Students continued to take the mechanical physics course as part of the agricultural department and provided labor on the farm as an “instructional and practical part of their education.”

Fairchild and Dudley organized the Engineering Course in close association with the other sciences. Sub-freshmen juniors and sub-freshmen seniors (essentially high school students) took courses in arithmetic, elementary physics and chemistry, Latin, English grammar and composition, book-keeping or history, algebra, geography, German, physiology and botany, and plane geometry. Freshmen took geometry, higher algebra or infantry tactics, physiology, and German. Sophomores had courses in chemistry, trigonometry, qualitative analysis, analytical geometry, calculus, analytical chemistry, and perspective and topographical drawing. Juniors had classes in mechanics, surveying, chemistry, physics, surveying and leveling, logic, calculus, and astronomy. Seniors completed their engineering coursework with courses in building materials, geology, metallurgy, framing methods, bridge construction, mineralogy, and roads, railways, and canals construction. Every year students had two or three history, philosophy, or modern language courses. But the students in the

²⁵ “University Faculty, Course of Study, and Agricultural College.” *Sixth Annual Bulletins and Catalogues of the University of Nebraska, Lincoln, October 1877* (Lincoln: Journal Company, State Printers, 1877), 7-35. RG 00/07, Bulletins and Catalogues, Box 1, Folder 6. University Archives / Special Collections – University of Nebraska-Lincoln. For a brief discussion of Fairchild’s introduction of the Industrial College, see Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 61.

engineering curriculum faced significantly fewer English, rhetoric, and philosophy courses than their classmates. In 1877, twenty-two students, out of fifty-five total in the University, designated themselves as part of the scientific course and industrial college.²⁶

The administration and faculty maintained their original plan for the Industrial College into the 1880s. In 1879, students who completed the engineering course began to receive the Degree of Civil Engineering and the University catalogue began designating them as engineering students. The faculty saw no reason to provide any detailed information for the department in that year's *Register and Catalogue*, noting only "The course of study in this department is hereafter set forth in full, and needs no special explanation." Whether the faculty believed they did not need to provide an explanation for what engineering was comprised of, or they simply didn't have the knowledge to do so, is debatable. However, the students did now have access to a complete course in engineering, distinct from the Literary and Agricultural Course. The faculty maintained the same selection of courses as introduced two years earlier. No specific "engineering" courses yet existed, but students did have the opportunity to take surveying, calculus, and applied construction and mechanics courses. Into the 1880s, students continued to make do with limited laboratory and field equipment. Faculty had access to "apparatus for illustrating the principles of physics," and equipment for

²⁶ In 1877 the University enrolled 55 total students in the University and another 160 students in the Latin and preparatory school. 14 women enrolled in the University and 81 women enrolled in the Latin school. University students could classify themselves as part of the Classical Course, Scientific Course, Literary Course, or Latin Scientific Course. There were 24 Classical students, 55 Scientific, 15 Literary, and 3 Latin Scientific. The Scientific Course was decidedly more popular with the newer students. "Industrial College and Courses of Study." *Sixth Annual Bulletins and Catalogues of the University of Nebraska, Lincoln, October 1877* (Lincoln: Journal Company, State Printers, 1877), 22-34. RG 00/07, Bulletins and Catalogues, Box 1, Folder 6. University Archives / Special Collections – University of Nebraska-Lincoln.

a chemistry laboratory. Faculty and students in the Industrial College and who worked at the model farm used donated tools and shared one transit and chain for surveying practice.²⁷

In March of 1881, University students encountered a significant shift in the University system. The Board of Regents accepted the faculty's recommendation to institute an elective system of study and to adopt a two term system instead of three. While students in the classical, scientific, and literary courses of study retained a majority of their courses and curricular structure, engineering and agricultural students now had to fit their three term instruction in practical training around an increase in history, language, and classical science courses. The administration moved military science classes so that they ran from January to March, allowing Isaac Webster, Dudley's 1879 replacement from the Military Academy at West Point, to instruct more students in surveying and construction practical work during the warmer months. However, the faculty did not include the Industrial College or its requisite curriculum in the new system. This meant students in the Industrial College classes remained on a three term system, while the rest of the University moved to a two term system. Science and engineering students simply had to fit their required courses into the "more flexible and specialized" elective system, while dealing with a complicated class schedule that included longer semesters of traditional coursework and shorter terms of applied study and practical training at the college farm.²⁸

²⁷ Only three students were officially recognized as Engineering majors and no graduates from 1879 to 1881 received the C.E. degree. However, 15 students majored in the scientific course and 5 of them were women. "Industrial College, Tabular Statement of Courses of Study, and Catalogue of Students." *Eighth Annual Bulletins and Catalogues of the University of Nebraska, Lincoln, October 1879* (Lincoln: Journal Company, State Printers, 1879), 23-29, 80-88. RG 00/07, Bulletins and Catalogues, Box 1, Folder 6. University Archives / Special Collections – University of Nebraska-Lincoln.

²⁸ "The Revised Courses and Courses of Study." *Prospectus of Revised Course of Study of the College of Literature, Science and the Arts, University of Nebraska, Lincoln, June 1881* (Omaha: The Globe Steam Printing House, 1881), 3-8. RG 00/07, Bulletins and Catalogues, Box 1, Folder 10. University Archives / Special Collections – University of Nebraska-Lincoln. The "Revised Courses and Courses of Study" proposal and plan

Chancellor Fairfield had helped the University make progress towards a more fully realized land-grant college curriculum. His work to organize the Industrial College offered farmers, mechanics, and engineers the possibility of a college education and better professional status. More importantly for Nebraskans, the students trained at the Industrial College had access to technical knowledge and practical training that might improve the farms and industries of the state, rather than draining away the promising young men and women of the state into more traditional professional endeavors, such as medicine, law, or theology.

Despite this educational success, Fairfield's chancellorship suffered from state political partisanship. Democrats, who controlled the Omaha newspapers and half the state legislature, repeatedly attacked the University throughout the 1870s and early 1880s as being a bastion of Republican ideology and "a haven for pastors who couldn't preach and faculty who couldn't teach." Democratic leaders fumed at the strong religious background of Board members and University administrators and faculty. And they labeled the agricultural college an "educational fraud and farce," stating that any farmer's son could learn more on a Cass County (a county south of Omaha in Douglas county) farm than at the University.²⁹

The Board recognized Fairfield's intellectual ability, but was disenchanted with his leadership abilities, to say the least. In their explanation for dismissing him in June 1882,

included the departments of philosophy, natural sciences, mathematics, Latin, Greek, Modern Languages, English, History, Physics and Chemistry, and Military Science. The Agricultural College and any connected engineering coursework did not get mentioned. Later catalogues indicate that the Industrial College remained on a three term system while the rest of the University operated with two terms. For instance, see the *Eleventh Annual Catalogue of the University of Nebraska for the Academic Year, 1882-83* (Lincoln: Journal Company, State Printers, 1883), 7-21. RG 00/07, Bulletins and Catalogues, Box 1, Folder 11. University Archives / Special Collections – University of Nebraska Lincoln.

²⁹ Robert Manley provides an in-depth analysis of the connections and conflicts between Republicans and Democrats, and the religious basis for much of the dispute in chapters 5-7 of his university history. He quotes prodigiously from the Omaha papers, which Democrats controlled, that attacked the Republican styles of Lincoln residents. He also quotes from letters of Lincoln residents and Lincoln newspapers, controlled by Republicans, in which University supporters attempted to fight back. See Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 47-75.

they noted “that the Chancellor had great zeal in his department, and possesses strong qualifications for special work. However, a lack of harmony and ‘irrepressible conflict’ in the Faculty led the Board to decide Fairfield’s retirement was in the best interest of the University.” The supporters of the University had suffered from numerous criticisms from the opening day. The Board had tired of constantly defending their decisions and the actions of the University administration and faculty during the 1870s. A combination of events changed the situation in the next decade.³⁰

The University began to prosper in the 1880s. The grasshopper plagues that destroyed the Agricultural College crops in the late 1870s came to an end and the structural problems of the first University Hall had been repaired. The religious debate ended when Fairfield left, and the improved state economy meant the Legislature provided more funding to the University. Citizens of eastern towns, which were mostly established cities along the Missouri River, still criticized and held grudges against Lincoln for holding on to the University when their area offered more prosperous towns, but the expansion and growth of western Nebraska towns and farms alleviated the state geographic rivalry to a large extent. The religiously minded critics also toned down their demands for theologically based education at the University by devoting attention instead to the founding of their own denominational colleges in the state. The administration, faculty, and students now had the opportunity to experience a strong and expanding university that could truly address the intellectual and practical needs of the state.³¹

³⁰ The Board’s statement regarding the dismissal of Fairfield is quoted in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 72.

³¹ Nebraskans supported a plethora of smaller private colleges during the 1870s and 1880s. Many closed or were acquired by different groups between the 1860s and 1890s. A few of these colleges still exist today, however,

The increase in population and progress in business, industry, and agricultural in the 1880s also helped the University and state prosper. The state's population rose from 452,402 in 1880 to 1, 058,910 in 1890. Railroad mileage increased from 1,868 miles to 5,144 miles during the same time period, mostly in the southwestern and northwestern regions of the state. Farmers claimed 19,585,382 acres of land, making Nebraska one of the largest food producers in the nation by the mid-1880s. The number of hogs and cattle tripled during the 1880s, prompting a dramatic expansion of the Omaha stockyards. A greater variety of farm implements, including the sulky plow, spike-toothed harrow, end-gate seeder, force-feed drill, and cultivator. Trained mechanics increasingly moved into western Nebraska towns to provide service and repairs for all of this new farm machinery. They often ended up opening their own implement dealerships in railroad towns where parts could be shipped in with greater ease.³²

Manufacturers tended to congregate in Omaha. Manufacturing increased from \$12.6 million in 1880 to \$93 million in 1890. Omaha businessmen built and expanded meat-packing companies. The Omaha and Grant Smelting Company consolidated with the Denver Smelting company in 1882. The owners had over one thousand employees, did \$21 million in business by 1892, and shipped in iron ore from Canada and Mexico. The Carter White Lead

including Doane College (Congregationalist, 1872), Creighton University (Jesuit, 1878), Nebraska Wesleyan College (Methodist, 1887), Dana College (Danish Lutheran, 1884), Hastings College (Presbyterian, 1882), Midland Lutheran College (Lutheran, 1883), Union College (Seventh Day Adventists, 1891), York College (Church of Christ, 1890), and Concordia College (Lutheran Church-Missouri Synod, 1894). Multiple state colleges also came into existence during the time period, including Peru State Normal school (1867), University of Omaha (later the University of Nebraska-Omaha), Wayne State Teachers College, Kearny State College (now University of Nebraska-Kearney) (1903), and Chadron State College (1911). See James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 257-259. For a more detailed study of early religious colleges in Nebraska see Ann L. Wilhite, "Books, Bibles, and Boosters: Colleges on the Urban Frontier of Nebraska Territory (1854-1867)," (M.A. Thesis, Creighton University, 1977). The interregnum period is briefly discussed in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 72-73.

³² James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 199-204.

Works used pig lead from the Omaha smelters to grow by 500% during the 1880s.

Manufacturers also started a linseed oil factory and a soap factory during the decade.

Business men also started brickyards, clothing factories, food processing plants, breweries, and distilleries in the booming city of Omaha. The dramatic growth of Nebraska's cities supported the growth of public education at all levels, especially at the state University.

However, University administrators and faculty still had to balance intellectual pursuits with the agricultural economy, and mechanic arts and engineering continued to lag behind other instructional areas.³³

The most prosperous and successful years of educational reorganization and instruction occurred under the watch of acting chancellors, between 1880 and 1900, rather than men hired specifically for the job. First, Henry Hitchcock, the professor of mathematics and dean of the faculty, and Charles Gere, a Board of Regent member, oversaw University functions from 1882 to 1884. Then Charles Bessey took charge of the University from 1888 to 1891 and from 1899 to 1900. Gere and Bessey guided the expansion of faculty, construction, and curriculum during their tenures. And Bessey did a great deal to more fully integrate the land-grant philosophy that he had brought with him from the Michigan Agricultural College, where he had been a student, and Iowa Agricultural College, as a professor.³⁴

Along with the change in administration and the elective system in 1883, two new faculty members contributed to the engineering and mechanic arts portion of the Industrial

³³ James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 204-208.

³⁴ The Chancellor position often changed hands during the middle of the academic year, depending on when an individual was dismissed or resigned. For a detailed list of Chancellors and Board of Regents members before 1927, along with their dates of service, see Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 313-314.

College. Richard Townley, a first lieutenant from the Naval Academy in Annapolis, took over the military science and tactics courses. Charles Little, first as a tutor and later as a full professor, became the instructor for higher mathematics and civil engineering. Little graduated from the University of Nebraska in 1879 with a Bachelor of Arts degree, and completed his Master of Arts degree in 1884, also at Nebraska. He went on to receive his Ph.D. from Yale University in 1885. Gere also added thirteen faculty members for the college of medicine and increased the University from ten to twenty. During the 1882-83 school year, total student enrollment reached 288 students, 53 of which were in the University proper and fourteen in the Industrial College. The rest filled the preparatory school and conservatory of music. Only three students were listed as engineering majors in the Industrial College, but the University did boost 95 women enrolled in its various programs and classes in 1883.³⁵

Gere and the faculty also officially recognized an established civil engineering curriculum before the 1882-83 academic year, probably hoping to attract more students with an official program. The science faculty, composed of Samuel Aughey, natural sciences, Henry Hitchcock, mathematics, Hudson Nicholson and L.F.M. Easterday, chemistry and physics, Richard Townley, military science, and Charles Little, mathematics and engineering, taught all the freshmen and sophomore scientific and engineering students. The identical curriculums allowed the limited number of faculty and lack of equipment and space to cover a

³⁵ "Faculty and Students." *Eleventh Annual Catalogue of the University of Nebraska for the Academic Year, 1882-83* (Lincoln: Journal Company, State Printers, 1883), 7-21. RG 00/07, Bulletins and Catalogues, Box 1, Folder 11. University Archives / Special Collections – University of Nebraska Lincoln. Little's background was never included in published University histories. The only known location for his educational background comes from the 1892 Catalogue, which included the degree, year, and school for each professor. See *The University of Nebraska Catalogue, 1892* (Lincoln: Published by the University, 1892), 5-61. RG 00/07, Bulletins and Catalogues, Box 2, Folder 9. University Archive / Special Collection – University of Nebraska-Lincoln.

greater number of students. Then, during their junior and senior years, students obtained instruction in higher mathematics and “technical study,” meaning they received more practical experience in surveying, metal and machine work and experimental or laboratory exercises. Students now had legitimate courses in calculus, surveying and leveling, railroad engineering, bridges and roofs, materials and stereotomy (stone cutting), and for the first time a full-fledged civil engineering course.³⁶

Engineering students entered an improving department, but it had a long way to go. The University had some equipment for the chemistry and physics laboratory, mostly for illustrative purposes, rather than actual experimentation and research. In fact, Nicholson brought his personal supply of chemical apparatus from Peru Normal, in Peru, Nebraska, leaving Peru students with nothing while more than doubling the equipment at the University. George Howard noted in a 1919 anniversary book that “rooms 103 and 104” of University Hall became the “cradle of the college of engineering. Professor Little developed a vigorous department of Civil Engineering.” Students certainly had a better curriculum to follow, but needed more practical training in the shop and field work that Nebraska’s industries and railroads required.³⁷

In addition to the engineering department improvements, Gere played an important role in bringing Irving Manatt to the University in 1884 to become the third Chancellor of the University. Manatt, a graduate of Yale and professor of Greek at Marietta College in Ohio,

³⁶ “The Industrial College.” *Eleventh Annual Catalogue of the University of Nebraska for the Academic Year, 1882-83* (Lincoln: Journal Company, State Printers, 1883), 32-33. RG 00/07, Bulletins and Catalogues, Box 1, Folder 11. University Archives / Special Collections – University of Nebraska Lincoln.

³⁷ Nicholson’s arrival at the University is noted in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 74. George Howard’s comment on Little was a small piece of his description of the early faculty in *The University of Nebraska (1869-1919), Semi-Centennial Anniversary Book* (Lincoln: By the University, 1919), 25. University Archives / Special Collections – University of Nebraska-Lincoln.

worked closely with the faculty to improve the curriculum, construct new buildings, and bring highly qualified individuals to Lincoln. In 1884, Manatt and Nicholson, the professor of chemistry and physics, requested \$75,000 for a laboratory and Industrial College Building. Manatt backed his funding request with the information that 295 students had enrolled in chemistry classes in the fall of 1883, but most had to be turned away. The laboratory only accommodated 20 people at one time and only two professors oversaw the chemistry classes and laboratory space. The legislature approved \$25,000 for a new Chemical Laboratory in 1883 and began increasing the funding for more faculty hires. While Manatt focused on increasing funding and providing more building space, Charles Bessey began reorganizing the Industrial College.³⁸

The arrival of Charles Bessey in 1884 initiated a dramatic period of instructional and philosophical change. Bessey brought his own brand of instructional method and a land-grant philosophy that had been ingrained at the Michigan Agricultural College in East Lansing, and sharpened at the Iowa Agricultural College in Ames. Bessey believed that land-grant institutions had to provide scientific instruction in agricultural and engineering, as required by the 1862 Morrill Act. His educational philosophy relied heavily on the concept of “science with practice,” which also happened to be the official slogan of Iowa’s land-grant institution. Bessey strongly believed that science and engineering students needed to learn skills that allowed them to acquire new knowledge over time, rather than offering everything to them at one time. He thought this was particularly true for engineers and mechanics, who might encounter a wide variety of construction or design problems in their jobs after graduation. With the resources he had available in Iowa, and later in Nebraska, Bessey incorporated real-

³⁸ Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 75, 82-83.

world experiences with laboratory research for chemistry, physics, biology, and geology. He especially wanted students to explore scientific principles in a natural setting and then investigate them further in the laboratory. His methods required funding, space, instructional and staff support, and time within the curriculum.³⁹

Bessey's first act as dean of the Industrial College was to submit a detailed report of the college, which included a purpose statement, the course of study, experiments, and collections. Bessey understood that each land-grant institution had interpreted the purpose of industrial education in a different way. He noted that many east coast and land-grant colleges, such as Cornell, and Iowa and Michigan's Agricultural Colleges had focused on manual labor and practical skills in the shops, farms, and gardens. These early colleges, he stated, had hoped that a combination of daily work and study hours allowed working class people the opportunity to acquire an education and an applicable skill set. Bessey clearly believed that schools that had utilized this method failed to meet with any real success. Industry had become too specialized, and Bessey strongly emphasized the point that no one could learn everything in one setting that would prepare them for the variety of real-world situations.⁴⁰

Bessey believed the true intent of the 1862 Morrill Act was to foster the underlying sciences of agricultural and engineering. Students who entered these fields would then acquire a firm foundation of knowledge which informed their practical training and would later allow them to continue to improving the knowledge and practice of their chosen field.

³⁹ Charles Bessey, "On a Scientific Course of Study," *The Aurora*, Vol. 5, No. 2 (May 1877): 5-6. Iowa State University Archives/Special Collections. The full length biography of Bessey analyzes his career at Iowa State and the University of Nebraska, his educational philosophy over time, and his connections to the rise of American Botany. See Richard A. Overfield, *Science with Practice, Charles E. Bessey and the Maturing of American Botany* (Ames: Iowa State University Press, 1993).

⁴⁰ Charles Bessey, "Industrial College." *Seventh Biennial Report of the Board of Regents of the University of Nebraska, December 1st, 1884* (Lincoln: Journal Company, State Printers, 1884), 33-34. RG 01/05, Regent Reports, Box 1, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

Bessey wanted his students to have a “personal acquaintance” with their areas of interest and study, to have first-hand knowledge built on experience, rather than knowledge amassed through reading what others had done.⁴¹

Bessey implemented this mission statement for the Industrial College with the full support of the faculty and over the next few years completely reorganized the curriculum to stress the importance of scientific knowledge and practical experience. He required a broad base of science courses for all students in the Industrial College, regardless of their major. He also mandated modern language courses, so that students could consult European books and periodicals. And finally, he broke the experimentation method into two parts, experiments which demonstrated principles and experiments which aimed to investigate phenomena and discover new principles. While the science faculty had used illustrative experiments since the University opened, Bessey opened the door for faculty and students to begin doing real research.⁴²

Bessey and the science faculty instituted a more rigorous curriculum beginning in 1885, though the three term system remained in place. Freshmen in the civil engineering program took chemistry, German, rhetoric and elocution, ancient history, zoology, geometry, trigonometry, and conic sections. Sophomores had courses in rhetoric, military science,

⁴¹ Charles Bessey, “Industrial College.” *Seventh Biennial Report of the Board of Regents of the University of Nebraska, December 1st, 1884* (Lincoln: Journal Company, State Printers, 1884), 34-35. RG 01/05, Regent Reports, Box 1, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

⁴² Charles Bessey, “Industrial College.” *Seventh Biennial Report of the Board of Regents of the University of Nebraska, December 1st, 1884* (Lincoln: Journal Company, State Printers, 1884), 35-38. RG 01/05, Regent Reports, Box 1, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln. Bessey also included most of his statements from the *Biennial Report* in the *Catalogue* the following year. See “The Industrial College.” *The University of Nebraska Catalogue, 1885-86* (Lincoln: By the University, 1886), 86. University Archives / Special Collections – University of Nebraska-Lincoln.

German or French, algebra, trigonometry, and geometry, graphics and drafting, and physics courses covering mechanics, acoustics, optics, heat, and crystallography.⁴³

Once they entered their junior and senior years, civil engineering students began acquiring significantly more practical and field experience. Juniors took differential and integral calculus, differential equations, physics topics in electricity, magnetism, acoustics, light, and heat, surveying work in the classroom and field, meteorology, rhetoric, and constitutional law. Seniors completed a senior thesis and focused on specialized engineering studies. These included field engineering, civil engineering, and an elective course in practical field work. Bessey's new curriculum provided significantly more specialization, while also requiring faculty to provide a much higher level of instruction in the classroom.⁴⁴

Bessey also asked for and spent significantly more money than any of his predecessors. In March of 1885 he asked for \$225.00 for laboratory equipment, \$300.00 for shelving, and \$200.00 for jars and cans which he used in his botany work. In June, he requested that a \$5000.00 appropriation bill be given to the legislature. Bessey allocated most of this money for laboratory specimens, microscopes, and laboratory furniture. In December,

⁴³ "Industrial College – Engineering Course." *The University of Nebraska Catalogue, 1885-86* (Lincoln: By the University, 1886), 48-50. RG 01/05, Regent Reports, Box 2, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

⁴⁴ Surveying work included land surveying, 3 hours of recitation, field work with compass and transit, 3 hours of platting surveys and computations, and 5 hours of surveying and leveling and field work with a level. Field Engineering consisted of locating the line of the railroad with calculations of excavations and embankments. Civil Engineering covered resistance of materials, strength of materials, bridge and roof construction, and at least 3 hours of classroom study. Elective courses in 1885 included projection drawing and drafting, descriptive geometry and drawing, stereotomy, land surveying with compass and chain, surveying and leveling with a level, railroad engineering (laying out curves, location of line, setting slope stakes, calculation of excavation and embankment, and transition curves), resistance of materials, bridge and roof construction, differential and integral calculus, differential equations, adjustment observations, method of least squares, analytical statics, conditions of equilibrium of systems of forces, friction, and attraction. Many of these courses were also required as part of the curriculum, so Bessey and the faculty must have offered them to seniors in order to more fully cover the entire curriculum. "Industrial College – Engineering Course." *The University of Nebraska Catalogue, 1885-86* (Lincoln: By the University, 1886), 51-52, 56. RG 01/05, Regent Reports, Box 2, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

he asked for another \$600.00 to pay various outstanding bills. In one year, Bessey spent over \$6000.00 just outfitting his botany laboratories and the science offices.⁴⁵

Bessey's spending helped boost the reputation of the university with students as well. During the 1870s, student enrollment remained below fifty students before 1875 and below 100 students before 1880. Between 1880 and 1885, student enrollment rose from 191 students to almost 300. By the late 1880s, more than 550 students took college level courses at the University. The number of students taking preparatory courses continued to drop as public high schools in the state gained accreditation from the University. Only fourteen students enrolled in the Industrial College in 1885, but within four years, nearly 80 completed agricultural or engineering degrees under the leadership of Charles Bessey.⁴⁶

Bessey benefited further from a stable faculty and curriculum. Where many other land-grant institutions, especially in the upper Midwest, had cycled through a number of faculty members in every discipline, the University of Nebraska kept its instructors for long periods of time. Between 1871 and 1890 the University lost just seven instructors in any of the scientific courses. During the same time, they hired twenty instructors or professors and by 1890, ten of them were still teaching at the University. Once Bessey and his Industrial College faculty introduced the reorganized curriculum in 1885, it remained virtually unchanged for years. In 1887, Bessey did delineate the engineering curriculum into three categories; the study of pure mathematics, surveying and other applied engineering practices, or graphics and drafting. Every student still had to take the full complement of courses, but

⁴⁵ Bessey to the Chancellor, letters dated 25 March 1885; 10 June 1885; and 15 Dec 1885. RG 01/01/01 Box 5, Folder 52-53. University Archives / Special Collections – University of Nebraska-Lincoln.

⁴⁶ Student enrollment data was compiled from the University Catalogue 1871-1900. See "Summary of Students." *The University Bulletins and Catalogues 1871-1882* and *The University of Nebraska Catalogue 1883-1900* (Lincoln: Published by the University, 1871-1900). RG 00/07 Bulletins and Catalogues, Box 1-2, Folder 1-7. University Archives / Special Collections – University of Nebraska-Lincoln.

this specialization allowed seniors to further specialize their area of training. This breakdown would have been especially important since the University of Nebraska still had no workshops for training mechanical engineers or offering any specialization in machine design. University graduates had to promote themselves to the railroads, local building and construction businesses, or find work in the drafting and design departments of engineering firms. In 1888, Bessey introduced an electrical course into the Industrial College to boost student enrollment in that specialized area of industrial growth. While a few other technical schools in the east had begun offering electrical engineering courses, Bessey effectively started one of the first full programs in electrical engineering. His efforts were largely supported by a physics department that desperately wanted to move beyond simple instruction and find a way to increase their laboratory research capabilities.⁴⁷

Bessey finished his third year as dean of the Industrial College on a strong note. In 1887, he and Irving Manatt persuaded the legislature to appropriate \$50,000 for the construction of a building dedicated to the Industrial College and affiliated science departments, later known as Nebraska Hall. Bessey and Manatt contracted the building for \$41,000, leaving the remaining \$9,000 for furnishings and laboratory equipment. Prior to 1888, the entire science faculty taught their lectures and laboratories in University Hall, a

⁴⁷ "The Course in Civil Engineering." *The University of Nebraska Catalogue, 1887-88* (Lincoln: By the University, 1888), 88. RG 00/07 Bulletins and Catalogues, Box 2, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln. "Elective Courses in Sciences – Electrical Course." *The University of Nebraska Catalogue, 1888-89* (Lincoln: Published by the University, 1889), 42. RG 00/07 Bulletins and Catalogues, Box 2, Folder 6. University Archives / Special Collections – University of Nebraska-Lincoln. Bessey actually had to argue with the Chancellor and Board of Regents about where the electrical course should exist within the University Curriculum. In his hand-written report for the Industrial College in 1888, Bessey explained that since electrical instruction fit within the physics coursework and the practical training fell within the oversight of the Industrial College's mandate to train practical farmers and engineers, then the electrical instruction naturally belonged within the Industrial College. The debate actually centered on which college would obtain the additional funding for equipment and instructional time. See Charles E. Bessey, "Report of the Dean of the Industrial College," handwritten report to the Chancellor dated May-June 1888. RG 1/1/1, Board of Regents Papers, May-July 1888, Box 7, Folder 62. University Archives / Special Collections – University of Nebraska-Lincoln.

poorly constructed and extremely small building. Most other universities of the same caliber as Nebraska's; Michigan, Wisconsin, and Iowa for instance, had already constructed multiple lecture halls, dormitories, and workshops by the mid-1880s. Nebraska's Board of Regents and University administrators had stuck to their original "slow-but-steady growth" plan, and as a result enrollment and progress in the sciences had suffered. Bessey began changing the philosophy of expansion and instructional spending immediately upon arriving in Lincoln, and continued his efforts throughout the remainder of his academic career at the University.⁴⁸

The rapidly expanding cities and towns in Nebraska helped push administrators and faculty to develop the mechanic arts curriculum at the university. Owners of meat-packing and smelting industries in Omaha relied increasingly on steam and electrical power to run and illuminate their buildings. City managers quickly turned to electric lighting over gas lighting as residents expanded city districts or built new towns along the railroads. And as the railroad managers pushed west, they brought the telegraph and electrical lines with them. So as towns sprouted up along the railroad lines, they automatically built their infrastructure with the resources provided by the rail companies. Local residents found they had an increasingly greater need for mechanics, electricians, and other technically trained individuals.⁴⁹

Despite the improvements in Nebraska's economy, Manatt paid a price for his vigorous support of higher appropriations and numerous building projects. While students and faculty recognized his abilities as a scholar and teacher, they also found him lacking in leadership qualities. Roscoe Pound, a graduating senior in 1888, complained that the

⁴⁸ "The New Buildings." *Ninth Biennial Report of the Board of Regents of the University of Nebraska, December 1st, 1888* (Lincoln: State Journal Company, Printers, 1888), 52-53. RG 01/05, Box 1, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

⁴⁹ James C. Olson and Ronald C. Naugle, *History of Nebraska*, 3rd ed. (Lincoln: University of Nebraska Press, 1997), 204-208. For a better description of the early telephone and electrical facilities in Nebraska towns see Dorothy W. Creigh, *Nebraska, A Bicentennial History* (New York: W.W. Norton & Company, 1977), 116-121.

Chancellor's post called for "a masterful man who could control a restless community, dominate the legislature, hold all manner of conflicting interests in check, and particularly hold down a suspicious student body." Pound probably echoed the frustrations of both faculty and community members. Manatt had alienated most of the faculty by micromanaging every aspect of the University and acting as the sole liaison between the Board of Regents and University staff. The student body refused to return in the fall of 1888 if Manatt retained his position as Chancellor, and the Board finally relented in July. Charles Bessey took over as acting Chancellor for three years, effectively overseeing the expansion of science courses across the curriculum and increasing the breadth and depth of the engineering curriculum.⁵⁰

By 1890, Bessey had increased the overall science faculty to fifteen professors and instructors, over fifty percent of the total University faculty. While Charles Little remained the only engineering professor, the engineering program was supported by two instructors in mathematics and physics, three instructors in chemistry, and supporting instructors in geology, drawing, military science, and Charles Bessey's overall leadership of the Industrial College. Students enrolled in Industrial College coursework increased to 76 students, up from just 14 in 1888, when Bessey took over as acting Chancellor. Requirements for admission grew to include mathematics through higher algebra and geometry, chemistry, physics, and botany. Classical and literary students remained shielded from the sciences, but had mathematics courses in algebra, geometry, and trigonometry. Industrial College students in all departments took mathematics through calculus, chemistry, physics, zoology, botany, military science, and geology. Depending on their majors, students then took specialized and elective courses in their individual fields. While Professor Little managed to increase the

⁵⁰ Roscoe Pound was quoted in Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 87-88.

specialization of the engineering courses, the program remained limited by the sheer lack of trained engineering faculty.⁵¹

Bessey continued his work to build and expand the university through his tenure as acting Chancellor. In his 1890 report to the Board of Regents, Bessey explicitly pointed out that the “law of Congress, which endowed the Industrial College,” the 1862 Morrill Act, had not been met by the Board of Regents or state legislature. Bessey pointed out that a lack of room and necessary funding, mostly for equipment, lay at the center of this failure. He also noted that mechanic arts “lay very near to every other industrial pursuit,” and that every area covered by the Industrial College was “largely dependent upon the Science of Mechanics in its broadest sense.” Bessey painted an optimistic picture for mechanic arts and the associated mathematics and science courses. However, his emphasis on “mechanical pursuits” clearly indicated that much greater attention to branches of engineering was needed in the immediate future.⁵²

When James Canfield arrived in the summer of 1892, Bessey had set the school on a firm foundation of growth and excellence. The University had grown to 58 faculty members and 883 students, 117 of them in the Industrial College. John J. Pershing had taken command of the Military Department and the Regents had organized and started the College of Law. The Summer School dramatically decreased the number of preparatory students and classes. The Experiment Station, funded by the 1887 Hatch Act, had been up and running for three years, and Bessey had begun a Farmers’ Short Course in the summer of 1892 with a total of

⁵¹ *The University of Nebraska Catalogue, 1889-90* (Lincoln: Published by the University, 1890), 7-9, 16-18, 35-52. RG 00/07, Bulletins and Catalogues, Box 2, Folder 7. University Archives / Special Collections – University of Nebraska-Lincoln.

⁵² Charles Bessey, “Plans for the Future.” *Tenth Biennial Report of the Board of Regents of the University of Nebraska, December 1, 1890* (Omaha: Henry Gibson, State Printer, 1890), 39-40. RG 01/05, Box 1, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln.

36 students attending. Students from 22 states and territories enrolled at the University of Nebraska in the fall of 1892, and the University had graduated 298 students, sixteen of them in engineering. A majority of the faculty held Ph.D.s, or at least master's degrees in their teaching area, and many had obtained their education at other land-grant institutions.

Engineering students finally saw an official expansion of their department in 1892. Administrators and faculty expanded the curriculum to include civil, electrical, and steam engineering groups. And after ten years of Charles Little serving as the sole engineering professor at the University, John J. Pershing, in military and civil engineering, Robert Owens, in electrical engineering, and Oscar V.P. Stout, in mathematics and civil engineering, joined him in the engineering department. Pershing, a 2nd Lieutenant in the U.S. Cavalry, also completed his law degree at the University and considered Nebraska his home for the rest of his life. Robert Owens received his undergraduate degree from Columbia and his electrical engineering degree from Johns Hopkins. Oscar Stout completed his civil engineering degree at the University of Nebraska in 1888, rejoining the staff after three years of field work.⁵³

Engineering students saw further expansion in 1893. While Bessey's curriculum had remained mostly unchanged since 1885, the increased number of faculty meant they could cover more topics. Along with graphics, surveying, railroad engineering, and building construction, upper level students now had access to materials engineering courses and classes in water supply and sewerage systems. Students in the electrical and steam engineering group

⁵³ *The University of Nebraska Catalogue, 1892* (Lincoln: Published by the University, 1892), 5-61. RG 00/07, Bulletins and Catalogues, Box 2, Folder 9. University Archive / Special Collection – University of Nebraska-Lincoln. Steam engineering was first mentioned in a special “Announcements” publication in 1892. See *The University of Nebraska, Six Years Instruction, Tuition Free, Announcements, 1892-1893* (Lincoln: Published by the University, 1892), 21-23. RG 00/07, Bulletins and Catalogues, Box 2, Folder 14. University Archives / Special Collections – University of Nebraska-Lincoln. The “civil and electrical groups” were first listed in *The University of Nebraska, The Colleges, Courses of Study, Departments of Instruction, 1892-1893* (Lincoln: Published by the University, 1892), 4-5. RG 00/07, Bulletins and Catalogues, Box 2, Folder 15. University Archives / Special Collections – University of Nebraska-Lincoln.

had courses in electrical measurement, dynamo and electrical machinery, principles of electrical installation, mathematical theory of electricity and magnetism, applied mechanics and mechanisms, machine design and mechanical drawing, steam engineering, and theory of prime movers. Though buried within the electrical engineering curricula the physics department provided, students now had mechanical engineering coursework available to them, though the University still didn't grant a mechanical engineering degree. In addition to the expansion of undergraduate courses, the faculty also expanded the graduate offerings, requiring one year for a Master of Arts degree and three years of additional work for a Ph.D. Civil engineers took a course in geodesy and any other instruction demanded by the faculty. Electrical engineers had to complete a full year's work in the field after completing their undergraduate curriculum. Students and faculty, at least in the electrical engineering field, now experienced much closer connections to professional engineers because of work related degree requirements which provided practical knowledge and experience, as opposed to the book and laboratory knowledge many universities focused on.⁵⁴

Charles Bessey played the most important role in bringing James Canfield to the University in 1891. Bessey had announced to the Regents in 1891 that he would resign rather than continue as acting chancellor. Bessey recommended Canfield, a professor of history and English literature at the University of Kansas as his replacement. Regent Gere also stepped forward to interview and recruit Canfield, along with Bessey, and in June 1891, Canfield agreed to come to Lincoln.

⁵⁴ *The University of Nebraska, The Colleges, Courses of Study, Departments of Instruction, 1892-1893* (Lincoln: Published by the University, 1892), 4-5, 13-14, 18-19, 33-35. RG 00/07, Bulletins and Catalogues, Box 2, Folder 15. University Archives / Special Collections – University of Nebraska-Lincoln.

Canfield brought a wealth of experience, knowledge, and skill to the leadership of the University. He grew up in an Episcopalian home in New England. He graduated from Williams College in 1868 and traveled as far west as his money would take him, which turned out to be Iowa. He worked for the railroad, eventually becoming a division superintendent for the Chicago, Burlington, and St. Paul Railroad. He passed his bar exams in 1872, and began working at the State University of Kansas in 1877. Canfield brought a religious upbringing, college education, practical engineering and management skill, and legal training with him to Nebraska. However, he connected with the working class as well. The historian Laurence Veysey noted that Canfield was a one of the men who “went west as a deliberate act of rebellion against gentility.” Canfield also worked to connect the education provided at state universities with the real problems and goals of the citizens of the state, especially the working class. It included infrastructure development, cultural opportunities, and educational improvements as just some of the problems prairie settlers struggled with and promoted their improvement as the fundamental goals that every state should support. Traditionalists hated him and the public loved him. Canfield supported students and the public to such an extent that the state legislature of Kansas stipulated that appropriated funds could not cover Canfield’s salary.⁵⁵

But Canfield had a contentious bunch of faculty members to deal with. By 1893, more than 40 of the 61 faculty members had worked at the University for more than five years, and many of those ten or more years. They had their established methods of operation, their educational philosophies, and their mandates for their programs and departments. Charles Bessey had given up the dean’s position in the Industrial College when he became the acting

⁵⁵ Robert N. Manly, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 113-116.

chancellor and he was replaced by Charles Ingersoll, an 1877 graduate of the Michigan Agricultural College. Ingersoll oversaw both the Industrial College and the Agricultural Experiment station, and led the Committee for a Mechanic Arts School. Ingersoll held steadfastly to the importance of mechanic arts in the other areas of the science and the industrial arts, much as Charles Bessey did. This was not surprising, considering both men came from the Michigan Agricultural School and had taught for several years at other land-grant institutions. But Ingersoll confessed to Canfield that the faculty members were “hopelessly divided in this matter. Brace and Owens [physics instructors] did not wish money taken from higher work, and do not believe in shop work. The literary men feel that the “tone” of the University will be lowered by this, and so on.” Canfield asked if what the faculty desired was really “a liberal education, the education of a gentleman, or even if you desire to be an expert in Civil Engineering or in Electrical Engineering, take any of these preparatory courses leading to the eight groups. If you are sort of an all-round chump and nothing but a farm hand, and you insist upon knowing something about agriculture and horticulture and training of the hand and eye, with which we have very little sympathy, go over there in the corner and stay there in that three years course.” Ingersoll and the rest of faculty backed off for the moment, and Canfield again managed to win favor with the working class students.⁵⁶

A month later, Canfield met with Howard Caldwell, the professor of history, who stated that “the lack of enthusiasm [among students and faculty alike] here was due to the fact

⁵⁶ Charles Ingersoll’s background was provided in the 1893 *Catalogue*. See *The University of Nebraska Catalogue, 1893* (Lincoln: Published by the University, 1893), 6. Canfield provided the quotes in his journal, James H. Canfield, *Chancellor’s Journal*. Entries dated 25 March 1893: 99-101, and 13 May 1893: 103. RG 05/07/01-02, James Canfield’s Journal 1891-1894, Box 1, Folder 1. Typed Copy of *J.H. Canfield’s Diary*, September 1994, by E.M. Johnson. University Archives / Special Collections – University of Nebraska-Lincoln.

that there was not and never had been any cooperation among the Faculty. On the contrary, individualism, jealousy, suspicion, and constant criticism were the norm. He attacked Nicholson,” the professor of chemistry, “as unfit for his work, and actually incompetent to teach higher chemistry.” That the professor of history found it necessary to comment on the chemistry professors abilities, provides a good example of the pettiness and discord among faculty members.⁵⁷

Traditional and science faculty both impeded the progress of the industrial arts. By the mid-1890s, the University had chemical and physics laboratories, but no work shops for training mechanics or engineers in any practical work. As cities and manufacturing, along with the necessary infrastructure, expanded after 1890, residents looked to the University, where administrators touted the importance of “practical skill” along with the improvement of intellectual and moral culture in society. However, students obtained all their field experience and hands-on training at the college farm or working on the University’s boiler or electrical systems. Graduates from eastern and other Midwestern colleges had better scientific knowledge and technical training than most University of Nebraska graduates. In addition, many faculty members despised the idea of any students performing manual labor. They wanted to focus their own efforts, with the assistance of students, on their own laboratory research and publications.

However, the growing connections between engineering education at all technical schools and professional engineering groups of every specialization began to slowly change faculty members’ educational philosophies after 1893. Of particular interest to many

⁵⁷ James H. Canfield, *Chancellor’s Journal*. Entry dated 6 July 1893: 107. RG 05/07/01-02, James Canfield’s Journal 1891-1894, Box 1, Folder 1. Typed Copy of *J.H. Canfield’s Diary*, September 1994, by E.M. Johnson. University Archives / Special Collections – University of Nebraska-Lincoln.

university professors and professional engineers was the new Society for Promoting Engineering Education, organized in Chicago at the 1893 Centennial Exposition. But changes to faculty and administrator education practices, if not the actual faculty and administrators themselves, would have to take place first, not just at Nebraska, but at all land-grant and technical institutions.

CHAPTER 7. ENGINEERING ASCENDANT – ENGINEERING EDUCATION AT MIDWEST LAND-GRANT COLLEGES, 1893-1900

Educators at late-nineteenth century Midwestern land-grant colleges developed a functional and professional form of engineering education. Administrators and faculty at these institutions led the way in developing a curriculum that both addressed applied technical skill and promoted the development of new scientific knowledge. These dedicated Midwest land-grant educators produced the majority of civil and mechanical engineers by 1900.¹

Educators and students experienced a fundamental and lasting shift from “mechanic arts” to “engineering” between the early 1890s and about 1900. Land-grant administrators hired more qualified and dedicated engineering professors who had specialized in distinct engineering fields such as civil, mechanical, electrical, and mining engineering. Administrators also acquired significantly more funding for their engineering departments, despite, or perhaps because of, the national economic depression which started in 1893. Professors directed these funds into improved laboratory equipment, more staff members, and new campus buildings. These professors also began attending national conferences and joining national engineering societies. This allowed professor to learn about national trends and professional expectations, while also allowing professional engineers to have more input into the educational process. Engineering graduates now entered the workforce better prepared to handle the demands of an increasingly technological society.

¹ Schools began providing more detailed statistics to the *Report of the Commissioner of Education* which the Secretary of the Interior’s office published. In 1899, the Midwestern land-grant schools in Michigan, Wisconsin, Iowa, and Nebraska reported producing a total of 1115 in just one year. The largest eastern schools, Cornell, Rutgers, and the Sheffield Scientific School of Yale produced only 866 for that year, and 774 of those graduates were from Cornell University, New Jersey’s land-grant institution. These statistics were compiled from tables in *Report of the Commissioner of Education Made to the Secretary of the Interior* (Washington: Government Printing office, 1899), 120-144. More information on engineering graduation statistics can be found later in this chapter.

Early engineering education in the Midwest depended on a mixture of frontier identity, modernization needs and perceptions, and educational philosophy and emphasis. While eastern schools focused on developing engineering laboratories during the second half of the nineteenth century, Midwestern educators continued to incorporate practical training as they adjusted and modified their curricula to meet the demands of residents of their region and the engineering profession. By the turn of the century, Midwestern states and their land-grant institutions had passed beyond their pioneer stages. Educators took a greater role in developing modern laboratories, curricula supported by professional engineers, and performing research relevant to their state's industry, as well as national manufacturing and business.

Each of the four Midwestern land-grant schools covered in this research had struggled through periods of trying to define themselves as land-grant institutions and trying to create a place for engineering. At Michigan's Agricultural College, faculty and students maintained a strong connection to the agricultural emphasis of the institution, while also working to improve the scientific knowledge, technical training, and field or practical applications that students had access to in their engineering studies. Perhaps more than in any other of the Midwestern states, Michigan's Agricultural College maintained a parallel pace with the state's industry in terms of practical training, so wood and metal working skills ebbed and flowed as part of the curriculum just as related industries did across the state.

In Wisconsin, University leaders focused on establishing the school as the leader of the state's entire education system and creating a top tier institution on par with older, eastern schools. Engineering students entered an institution fundamentally different than at Michigan or Iowa. While officials at those schools tried to balance agriculture and mechanic arts,

Wisconsin and Nebraska built curricula based on a more classical system of humanities, languages, and rhetoric. However, since the 1862 Morrill Act mandated sciences as part of an agriculture and mechanic arts focus, administrators had to incorporate them into the institutions course offerings. Wisconsin presidents and faculty worked under persistent funding problems, but they used the scientific and engineering offerings to promote the University as an important institution for improving the state and assisting with the modernization of the state's economy.

Iowa and Nebraska administrators used a similar mentality in improving their engineering programs. At Iowa's Agricultural College, the land-grant mission to provide agriculture and mechanic arts guided the instruction from the very start. While presidents and professors emphasized their own methods of instruction, leading to cycles of more practical instruction and then more balanced instruction between classroom instruction and applied training, by the 1890s the pendulum swings settled down in favor of strong scientific theory combined with applied research investigation. At Nebraska, early college presidents attempted to downplay the industrial college and its efforts. Charles Bessey slowly turned the scientific and technical instruction around after 1885, providing more practical training and improving the scientific research that faculty could engage in. Nebraska's faculty and later administrators promoted the engineering program as a way to not only improve manufacturing within the state, but also to entice businessmen and industries to come to the frontier state, since land was cheap and labor would be in a ready supply.

Despite the different approaches, faculty and administrators at all these schools dealt with a combination of frontier character, which called for self-reliance and establishing a unique identity within the pattern of American culture, modernization demands, to support

agriculture and industry at their most efficient and productive levels, and educational elitism, to construct a system of instruction that stood as a leader within their state and for other land-grant institutions and universities. As these schools entered the 1890s and moved closer to the turn of the century, the nature of professionalism and expertise firmly infused the training of engineers. Faculty, increasingly trained in laboratories as part of cutting edge research, emphasized high levels of scientific and mathematical knowledge in conjunction with systematic research, both applied and purely scientific. Engineers gained new professional status as the culture of technical knowledge they existed within adapted to the educational trends of the land-grant universities and embraced the workplace demands of a modern, industrial society.²

The Michigan Agricultural College

In the 1890s, engineering students in Michigan entered a progressive culture of technical knowledge. Faculty members at the Michigan Agricultural College placed a great deal of importance on advanced instruction, applied training, and laboratory research. Michigan businessmen helped build an industrial base in forestry, railroads, automobiles, and the emerging market of chemical production that relied on well trained and well-rounded engineers and scientists. As industry grew and the College became a more useful institution of the state, administrators and faculty worked to expand the engineering programs that benefited the state.

While the college's engineering program had grown strong by the 1890s, administrators struggled to address problems remaining in other areas of the Agricultural

² Alan Marcus discussed the nature of engineering and professionalism as a part of the systemization of American education and improved methods of research in Alan I Marcus and Howard Segal, *Technology in America, A Brief History*, 2nd ed. (New York: Harcourt Brace College Publishers, 1999), 138-141.

College. Between 1889 and 1893, Oscar Clute lost forty faculty members in thirty teaching and research positions. Most faculty and staff left for better paying positions or career advancement. Many new land-grant colleges recruited hires from the Michigan Agricultural College as one of the few places they could acquire a well-trained scientist, agricultural instructor, or administrator who knew how to run a program based in agriculture and the mechanic arts. Eugene Davenport, the professor of agriculture, left in 1891 to become the president of the agricultural college at Piracicaba, Brazil, where the founders hoped to establish a “little Lansing.” South Carolina Governor, Benjamin R. Tillman consulted Clute on a number of occasions, and then requested that Clute send him a trained agriculture professor to serve at his state’s newly-established Clemson University, while praising Michigan by saying, “your school is the pioneer and guide for all similar institutions.”³

While the outside recruitment of staff and students away from Michigan benefited the reputation of the Agricultural College in many ways, their graduates filled the engineering ranks across the nation and their professors spread the Michigan land-grant philosophy, new hurdles for the Agricultural College appeared. Michigan engineering students had a good grounding in science and received extensive practical training. However, mechanical students began rebelling against the manual labor hours they were required to perform on the University farm. As early as 1885, mechanical arts and engineering students developed a form of sabotage, since they felt the shop skills they had come to college to acquire had nothing to do with hoeing corn or milking cows. While unsupervised in the fields, students would “find a shady place, posting one of their number as a lookout. When a foreman

³ Madison Kuhn, *Michigan State, The First Hundred Years, 1855-1955* (East Lansing: The Michigan State University Press, 1955), 169-172, 176-177. Numerous other professors also left the Michigan Agricultural College and ended up at other land-grant universities in the upper Midwest. For instance, E.A. Burnett, an 1887 graduate and instructor in livestock and husbandry eventually became the Dean of Agriculture and Chancellor at the University of Nebraska. Perry Holden, an 1889 graduate, ended up at Iowa State University where he created the first department of agricultural extension.

approached, a warning went up and they would return to work.” A graduate later noted that “one honest freshman did as much work in a day as two sophomores, three juniors and five seniors.” This open revolt towards the manual labor system, based in agriculture, demonstrated the students’ sense of the growing status of engineering and the value of more specialized training over simple manual labor.⁴

Beginning in 1891, the strength of Michigan’s engineering programs grew, based on the fact that faculty members stayed at the College long enough to realize a long-term vision for curricula, training programs, and research projects. Herman Vedder arrived in 1891 and finally retired in 1925. Charles Weil came to East Lansing in 1893 and stayed until 1906. These two men oversaw a series of shop superintendents and instructors, while implementing educational philosophies that guided the civil and mechanical engineering programs through a decade of regional and national change in industry and professional status.

Through his thirteen years at that Michigan Agricultural College, Charles Weil oversaw an expanded mechanical engineering department. He and his staff instructed more students than had ever enrolled before, had more laboratory space and research equipment, and enjoyed an overall improvement in the acceptance and status of the program within the Agricultural College.

Weil focused his attention on running the department and instructing senior level classes. Seniors had courses in thermodynamics, valves and gears, graphical statics of mechanisms, a steam engineering laboratory, engineering practice, and thesis work with Professor Weil. Along with the laboratory and shop work overseen by other staff members, Weil implemented and maintained an engineering program that developed extensive scientific

⁴ Madison Kuhn, *Michigan State, The First Hundred Years, 1855-1955* (East Lansing: The Michigan State University Press, 1955), 173-174.

knowledge along with practical expertise in modern engineering applications, such as steam engineering, machine design, and materials testing.⁵

By the mid-1890s, Charles Weil had five staff members to assist him in the mechanical department. Paul Chamberlain, an 1888 graduate and professor of mechanical engineering at Lewis Institute, worked with seniors in the experimental laboratory and instructed sophomores in workshop methods. Juniors and seniors received instruction in steam engine design and kinematics and machine design from Allen Westcott, another 1888 alumnus. These professors had more time for classroom and laboratory work since three men in the foundry and other workshops now helped oversee student work performed during the week.⁶

Weil attempted to balance the instructional methods of his staff and coursework to give students what he considered the proper perspective on engineering as an applied science. He stated in his reports to the Board that he and his staff stressed “both ‘theory’ and ‘practice,’” and avoided tending to an excess in either direction.” Weil replaced departing shop supervisors with Agricultural College graduates, so that his educational philosophy might be more strongly ingrained in current students. While students continued to produce finished equipment and machinery in their shop work, Weil emphasized that their work also allowed students to “obtain as broad a view and understanding of methods and machines as

⁵ Charles Weil, “Report of the Mechanical Department.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 45-47. Michigan State University Archives and Historical Collections. Electrical Engineering students took their courses within the Physics department under the direction of Philip Woodworth, another long term professor of the University. Woodworth oversaw the classroom instruction, but had to rely on the equipment provided by the mechanical department to conduct the practical instruction. See Philip B. Woodworth, “Report of the Department of Physics.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 84. Michigan State University Archives and Historical Collections.

⁶ Charles Weil, “Report of the Mechanical Department.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 45. Michigan State University Archives and Historical Collections.

possible in the allotted time.” To this end, students produced practical equipment that furthered shop practice and laboratory experimentation, such as a hydraulic hoist, electric motors, wood and metal lathes, and even a Van Winkle Dynamometer for the electrical engineering laboratory.⁷

Weil also “outsourced” his students to local industries. Beginning in 1895, he sent several students a year to perform engine and boiler tests on the steamship Rappahannock, and to Jackson and Lansing to shadow engineers at mechanical workshops and engineering firms. Weil noted that “it was highly desirable for the students and college to bring them into touch with working engineers, and experimental work.” Weil and Chamberlain also began regularly attending the annual meeting of the American Society of Mechanical Engineers, held in Detroit in 1895, so that they could better understand the professional requirements and expectations that their engineering students would encounter after graduating.⁸

Herman Vedder followed a similar education philosophy for the Mathematics and Civil Engineering Department. Vedder and his staff of three instructors increased the number of classroom hours, expanded the field work experience to include more hours and varied surveying skills, and began requesting more specialized laboratory research funds and space to accommodate the growing number of geological and hydraulic investigations requested by students and the public. Vedder reported in 1895 that over six hundred students had enrolled in his mathematics and engineering courses, far surpassing the totals from previous years,

⁷ Charles Weil, “Report of the Mechanical Department.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 46-47. Michigan State University Archives and Historical Collections.

⁸ Charles Weil, “Report of the Mechanical Department.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 47. Michigan State University Archives and Historical Collections.

which typically numbered around two or three hundred students, mostly in required mathematics courses for freshmen and sophomores.⁹

Like Weil in mechanical engineering, Vedder also added Agricultural College graduates to his staff. C.C. Pashby took over several of the entry level mathematics and mechanical courses in 1895, and Warren Babcock, who remained at the University until the 1920s, taught numerous mathematics and materials testing courses. Vedder made do with what laboratory space he could share with other departments, but he had already begun requesting more space and equipment funding by the early 1890s, especially to investigate mechanics of fluids and hydraulic principles as they related to civil engineering.¹⁰

Vedder and his staff also oversaw the improvement and maintenance of the college infrastructure. Beginning in 1894, he and his students surveyed for the extension of the sewer system to the agricultural laboratory, as well as surveying for the removal and reinstallation of sewer systems for the Abbot and Wells dormitories. Students and staff also helped with the leveling work for the Lansing street railway, designed the iron floor system for the proposed dairy building, and made surveying measurements of all the buildings on campus. While his department lacked research laboratory space, Vedder made sure his students had a wealth of practical experience they could rely on when they entered the professional engineering ranks.¹¹

⁹ Herman K. Vedder, "Report of the Department of Mathematics and Civil Engineering." *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 79-82. Michigan State University Archives and Historical Collections.

¹⁰ Herman K. Vedder, "Report of the Department of Mathematics and Civil Engineering." *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 79-80. Michigan State University Archives and Historical Collections.

¹¹ Herman K. Vedder, "Report of the Department of Mathematics and Civil Engineering." *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 81-82. Michigan State University Archives and Historical Collections.

Vedder also made the Board aware that he had begun attending the annual conference for the Society for Promoting Engineering Education in 1894. He noted that society organizers of the conference in Brooklyn, New York, aimed to focus on “shaping the development of our engineering schools, especially the newer and smaller ones.” He also noted that the society hoped to “influence the work in preparatory schools whose students intend to take a complete course in engineering.” Vedder was impressed by the number of teachers who attended the conference, and testified to the benefits the society brought to engineering nationally and to the Agricultural College through greater organization and standardization.¹²

By 1896, Michigan administrators were forced to address the sharp contrast between the growing success of the engineering programs and the apparent decline of agricultural instruction. The investigating committee reported to the Board of Trustees that the “the popularity of the college with that class of people in whose special interest it was organized” had drastically fallen. Through letters, newspaper articles, personal interviews, and alumni reports, along with evidence from other agricultural colleges and even European technical schools, the committee members concluded that while attendance steadily increased, the curriculum and programs of study at the Agricultural College had moved away from instructing the farmers of the state in order to focus on producing graduates for the business sectors. Professors offered entry level instruction well beyond the ability of most students from working class and farm backgrounds, especially those who did not complete their primary or secondary education at state supported public schools. Also, many students could

¹² Herman K. Vedder, “Report of the Department of Mathematics and Civil Engineering.” *Thirty-Fourth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1894 to June 30, 1895* (Lansing: Robert Smith & Co., State Printers and Binders, 1896), 82. Michigan State University Archives and Historical Collections.

no longer afford the entry fees or tuition since the free tuition provided by the 1862 Morrill Act funding had long since run out. As professors focused more on business practices and fields, more students came from the middle-class. Working-class students who did attend the Agricultural College also tended to not return to farms or smaller communities. While the committee noted that some complaints were exaggerated or reflected long-held perceptions of the Agricultural College rather than reality, they stressed that the shift away from working class interests represented a bigger national and even international trend.¹³

To combat the growing problems of both real and perceived academic elitism at the Agricultural College, the committee proposed a number of actions. First, they asked for an “authoritative definition of the character of our agricultural and mechanical courses.” Based on the experience and educational philosophies of many long standing professors, such as Weis and Vedder, the committee offered the following definition: “The Michigan Agricultural College is a school for technical and professional training in farming and engineering. Its aim is to develop all its pupils into broad-minded men, good citizens and ideal farmers or mechanical engineers. Its methods are, science applied to all duties and labors, united action of brain and hand and eye until skill is attained, development of character through ‘the blessed companionship of wise thoughts and right feelings.’” Clearly, the faculty and administration held to the original mission of the land-grant act to educate the “industrial classes” in agriculture and mechanic arts. They also benefited from a state university and college system that supported a classical university in Ann Arbor, a normal school in Ypsilanti, and two more regional schools in Albion and Olivet. Agricultural College supporters, faculty, and

¹³ Howard Edwards, Clinton Smith, and F.S. Kedzie, “Attendance at Agricultural College.” *Thirty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1895 to June 30, 1896* (Lansing: Robert Smith Printing Co., State Printers and Binders, 1897), 57-68. Michigan State University Archives and Historical Collections. The particular struggles of the 1890s are also analyzed in Madison Kuhn, *Michigan State, The First Hundred Years, 1855-1955* (Lansing: The Michigan State University Press, 1955), 1887-195.

administrators could afford to be specialized and focused. Administrators and instructors at land-grant schools in many other states did not have as much leeway in their schools' mission or specialized focus.¹⁴

Jonathan Snyder's arrival in 1895, as the new president of the University, began a long period of stable administrative leadership at the Michigan Agricultural College which complemented the work of faculty and other instructors. Snyder had acquired extensive executive experience as an administrator in Pennsylvania high schools. His Ph.D. in psychology and pedagogy from Westminster College made him rather unique at the Agricultural College, since William Beal held the only other Ph.D. at the Agricultural College and it was an honorary degree from the University. Snyder brought with him a distinguished resume in leadership and organization, as well as experience with manual training and home economics programs, agricultural research knowledge, and a "youthful zest complemented by a dignified bearing." Snyder wanted to improve the College's curriculum and status in the state as an institution of higher learning that benefited all citizens.¹⁵

Snyder immediately set to work innovating and modernizing the curriculum. He oversaw the transition from a long winter vacation to a summer vacation, an increase in women's courses, and the start of four special six-week courses during the winter break for agricultural students. Snyder believed these changes kept the Agricultural College in line

¹⁴ Howard Edwards, Clinton Smith, and F.S. Kedzie, "Attendance at Agricultural College." *Thirty-Fifth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1895 to June 30, 1896* (Lansing: Robert Smith Printing Co., State Printers and Binders, 1897), 57-68. Michigan State University Archives and Historical Collections. The official college newspaper ran several stories between 1896 and 1899 supporting their vision of the Michigan Agricultural College mission and what they believed the 1862 Morrill Act fundamentally stood for. For instance, see "Industrial Education." *The M.A.C. Record*, 17 November 1896: 4-6; Philip B. Woodworth, "Physics and Farming." *The M.A.C. Record*, 1 June 1897: 3; R.C. Kedzie, "Chemistry as Related to Agriculture at M.A.C." *The M.A.C. Record*, 1 June 1897: 3; "A Superior Mechanical Course for Little Money." *The M.A.C. Record*, 23 November 1897: 1; and W.J. Beal, "Senator Morrill as Statesmen." *The M.A.C. Record*, 24 January 1899: 3. Michigan State University Archives and Historical Collections.

¹⁵ Madison Kuhn, *Michigan State, The First Hundred Years, 1855-1955* (East Lansing: The Michigan State University Press, 1955), 196-197.

with other American Universities, and allowed the curriculum to keep pace with modern instructional trends that focused on professional skill and status rather than manual labor.¹⁶

Snyder and Weil effectively meshed their respective goals to produce a successful and progressive engineering program. In 1897, Weil reported that at the annual convention of the Michigan Engineering Society, held at the College that year, the society members had passed a resolution expressing their “appreciation of the technical training furnished by the great educational institutions of the State.” They also recommended that “all young men, who have any branch of engineering in view as an occupation, to avail themselves of the advantages offered by these institutions.” Weil hoped to show the board that his engineering programs had attained a regional following which professional engineers saw as beneficial to their work.¹⁷

Weil took the opportunity to promote the practical nature of the engineering program in an article, or more precisely an advertisement, for *The M.A.C. Record* in 1898. He focused on lower-class individuals and working class men as the primary target for the engineering program at the Agricultural College, which he declared could best serve their educational

¹⁶ J.L. Snyder, “Report of the President.” *Thirty-Sixth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1896 to June 30, 1897* (Lansing: Robert Smith Printing Co., State Printers and Binders, 1898), 26-28. Snyder detailed several improvements in women’s education at the college, primarily based on bringing scientific knowledge into the home. Many other publications during the time period also discussed the improvements in women’s education at the Agricultural College. For instance, see J.L. Snyder, “Women at the Michigan Agricultural College.” Typewritten address dated 1895. UA 2.1.7 Snyder Papers, Box 867, Folder 18; Mary A. Mayo, “Practical Education for Young Women.” Typewritten address dated 14 April 1896, UA 17.107 Kuhn Collection, Box 1141, Folder 38; Mary A. Mayo, “Does Education lead to Extravagance.” Typewritten address dated 1896, UA 17.107 Kuhn Collection, box 1141, Folder 38; Professor Edith F. McDermott, “Domestic Science.” *The M.A.C. Record*, 29 September 1896: 1; J.L. Snyder, “Industrial Education.” *The M.A.C. Record*, 17 November 1896: 4-5; Grace M. Lundy, “Our Cooking Laboratory.” *The M.A.C. Record*, 9 February 1897: 2; “Women’s Course at the Agricultural College.” and “Domestic Science in the Women’s Course.” and “Physical Training for Women at M.A.C.” *The M.A.C. Record*, 25 September 1900: 2; “Education for Our Women – Of What Shall it Consist?” *The M.A.C. Record*, 2 October 1900: 1-3; “The Culture Value of the Women’s Course.” and “The Sciences in the Women’s Course.” *The M.A.C. Record*, 14 March 1901: 1-4. Michigan State University Archives and Historical Collections.

¹⁷ Charles Weil, “Report of the Mechanical Department.” *Thirty-Sixth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1896 to June 30, 1897* (Lansing: Robert Smith Printing Co., State Printers and Binders, 1898), 42-44. The Michigan State University Archives and Historical Collections.

needs. He mentioned that while the program principally centered on mechanical engineering, electrical and civil engineers also gained a solid grounding in scientific principles and practical skills. He spent a great deal of time describing the workshops and laboratories as places where students enhanced skills and used modern equipment, while the laboratory allowed students to expand their knowledge in the realms of materials testing, machine design, and steam engine operation. Weil emphasized the fact that almost every student who entered the program found good employment in engineering following graduation. Alumni even wrote in to say their company bosses asked them to request more Agricultural College graduates be sent to their businesses.¹⁸

Snyder noted the increase in engineering interest in his 1899 report to the Board. He mentioned that attendance had increased by over one hundred students in just one year, and “faculty and students were enthusiastic, and worked together with gratifying results.” The largest increase was in mechanical engineering, which paralleled an increased demand for mechanical, civil, steam, and electrical engineers from manufacturing and business. Farm boys went into the engineering field in increasing numbers, and Snyder felt that if that movement continued, it was because farming needed better engineers rather than better scientific farmers, and farm boys recognized more opportunities for success in the cities, rather than on increasingly mechanized farms which needed fewer workers.¹⁹

¹⁸ Charles Weil, “Mechanical Engineering at M.A.C.” *The M.A.C. Record*, 26 April 1898: 1. The Michigan State University Archives and Historical Collections.

¹⁹ J.L. Snyder, “Report of the President.” *Thirty-Ninth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1899 to June 30, 1900* (Lansing: Wynkoop Hallenback Crawford Co., State Printers, 1900), 21. The Michigan State University Archives and Historical Collections. Snyder also spent a fair amount of time responding to letters during his presidency, many of which focused on the student or parent requests for engineering preparation or acceptance into the College. For instance, Fred C. Dauncey to J.L. Snyder, letter dated 24 July 1901; J.L. Snyder to Fred C. Dauncey, letter dated 27 July 1901; J.L. Snyder to Mrs. J Jerome Davis, letter dated 24 July 1901; and J.L. Snyder to Harry Douglas, letter dated 30 July 1901, UA 2.1.7 Snyder Papers, Correspondence D July 1901, Box 805, Folder 57. The Michigan State University Archives and Historical Collections.

Recent scholars of Michigan's Agricultural College institutional history have noted that Snyder, Weil, and Vedder differed greatly in their educational philosophy and approach. Historian Keith Widder has argued that Vedder stressed the practical and Snyder "never wavered from his commitment to the theoretical, fearing that otherwise the Agricultural College might become a mere trade school. According to Widder, Snyder maintained that technical instruction must always include theoretical classroom work combined with laboratory and workshop training. However, Widder only based his observations on later Snyder documents, well after the turn of the century. During the 1890s, Snyder displayed a strong commitment and understanding of what Weil and Vedder were attempting to do within the engineering program in terms of maintaining a balance between theoretical instruction and applied practice. Additionally, Weil and Vedder had a long standing dedication to practical training combined with scientific knowledge, especially during the 1890s."²⁰

While educators discussed how best to approach the necessary instruction of students, the frontier industries which had played a role in how the Agricultural College approached instruction were coming to end. Michigan lumbermen had largely exhausted the forests of the state by 1900. Domestic manufacturing, which most frontier settlers had earlier relied upon for their basic needs, had been replaced by large scale manufacturing centered in cities and near power and transportation centers, meaning rivers and lakes. Artisans and craftsmen continued to produce goods for specialized purposes, such as cabinetry and fine iron work.

²⁰ Keith R. Widder, *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 135-136. Widder managed to condense the history of engineering between 1855 and 1925 into less than eleven pages, most of which discussed the period after 1910. Most of his references relied on letters and university documents after 1907. Most of the references for engineering are in footnotes 106-117.

But again, large scale manufacturing, promoted by catalogues such as Sears and Roebuck, had captured most of the market producing machinery and tools needed by farmers and industry.²¹

Additionally, the rise of the automobile industry during the 1900s and 1910s began to necessitate a change in how engineers approached their work, driving a new focus on machine design and materials or construction principles, rather than shop work which focused on iron and wood working skills. Finally, the growth of transportation in the southern half of the state changed the nature and emphasis of business, shifting Michigan's priorities away from local or regional manufacturing, to a state rapidly assuming a place in the national industrial and big business model that emerged during the 1890s. Businessmen had to find ways to innovate in order to make money, and scientists working research labs and engineers working on practical applications became a hot commodity.²²

Michigan Agricultural College's engineering students encountered many changes in both their educational institution and their profession after 1900. The dramatic increase in students which occurred near the turn of the century necessitated another round of funding requests from Snyder, Weil, and Vedder in their 1900 reports to the Board. These professors maintained a network of business connections and knew they needed to improve their departments' offerings and training methods in order to attract more students. They prioritized the acquisition of manufacturing quality shop equipment and aggressively pursued

²¹ On the growth of manufacturing and the automobile industry in Michigan see Willis F. Dunbar, *Michigan, A History of the Wolverine State*, 3rd ed. (Grand Rapids: William B. Eerdmans Publishing Company, 1995), 393-442. For an analysis of national industrialization, the trend towards mass production, and electrification of power sources see David Hounshell, *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States* (Baltimore: The Johns Hopkins University Press, 1984); and Thomas P. Hughes, *Networks of Power, Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983).

²² For an analysis of how engineering and manufacturing became more closely aligned see Edwin T. Layton, *The Revolt of the Engineers, Social Responsibility and the American Engineering Profession* (Baltimore: The Johns Hopkins University Press, 1986); and David F. Noble, *American by Design: Science, Technology and the Rise of Corporate Capitalism* (New York: Oxford University Press, 1977).

industrialists to support their laboratory research with funding which the state alone would not be able provide.²³

Reflecting a deepening connection between the school and the state automobile industry, Ransom Olds opened his business and personal pocketbooks to help build and outfit a new engineering building in 1907, and again in 1916, to the tune of \$100,000, following a fire which destroyed the engineering building and workshops. But by this time, engineers had entered a new phase of educational mandates from the public and professional spheres which included more research and publications for faculty and even more business and management training for students. Industrialists and manufacturers retooled their businesses to meet the new demands of scientific management and mass-production methods that relied on production flow, electrical power, and other new systems of operation.²⁴

The University of Wisconsin-Madison

While engineering faculty and students at the Michigan Agricultural College benefited from the support of industry, other school administrators focused on their own initiatives for improving institutional prestige and preeminence within their state. Wisconsin administrators and faculty focused on centralizing the entire public education system within the state by coordinating the system through the University. In order to educate well rounded teachers for

²³ Weil and Vedder both asked for more space and equipment on a consistent basis. In 1900, they both mentioned that they had run out of space. See Charles Weil, "Report of the Mechanical Department." and Herman Vedder, "Report of the Mathematics and Civil Engineering Department." *Fortieth Annual Report of the Secretary of the State Board of Agriculture of the State of Michigan, July 1, 1900 to June 30, 1901* (Lansing: Wynkoop Hallenbeck Crawford Co., State Printers, 1901), 38-40, 67-71. The Michigan State University Archives and Historical Collections.

²⁴ Widder describes many of the changes which occurred between 1907 and 1916. See Keith Widder, *Michigan Agricultural College, The Evolution of a Land-Grant Philosophy, 1855-1925* (East Lansing: Michigan State University Press, 2005), 135-141. On the new systems of production and management see Alan I Marcus and Howard Segal, *Technology in America, A Brief History*, 2nd ed. (New York: Harcourt Brace College Publishers, 1999), 183-205.

the elementary and secondary school systems, University faculty members in Madison had to embrace a full curriculum of both classical and scientific studies.

In the 1890s, Wisconsin administrators and faculty expressed particular concern about their institution's national status. By the early 1890s, administrators claimed that they had largely equaled their eastern counterparts, such as Harvard and Johns Hopkins, in terms of scientific and humanities studies. While self-promotional rhetoric was common among Midwest boosters in the nineteenth century, the aims of the Wisconsin University administrators underlines the need that land-grant universities felt to compete scholastically with long-established schools and to justify their intellectual existence. Charles Adams, who oversaw the growth and educational focus of the University of Wisconsin as president from 1892 to 1902, utilized a combination of his Midwestern and East coast experiences to enhance the institution's visibility and reputation.

Born and raised in Vermont, a short stint in Iowa before college, and educated at the University of Michigan, Charles Kendall Adams brought an innate sense of pioneer mentality and working class culture with him to Wisconsin in 1892. He also developed a keen awareness for educational management and promoted progressive educational philosophies. After a year of study in Germany, he promoted the German seminar system at every institution he worked at. Adams spent a great deal of his personal research time on the history of education and the relationships between knowledge, skills, and the success of the state and nation, in America and Europe. As a result of his research and extensive writings on American history and education, he diligently promoted the idea that higher education, based in scientific principles and applications, lay at the foundation of national prosperity.²⁵

²⁵ Charles Kendall Adams was born in Vermont in January 1835 and went through his primary education there. He completed his high school and college preparatory education in Denmark, Iowa when his family moved there

Adams led the University of Wisconsin by example. He combined his own interests in history with the growing importance of scientific knowledge and the applications necessary to improve the public setting. Adams saw in Wisconsin's state institutions the most progressive educational policies available, publicly supported education from the lowest grade schools through graduate studies using modern seminar and laboratory research methods. Adams had enthusiastically supported Robert Thurston and his expansion of the engineering laboratories at Cornell University while Adams was president of Cornell. However, his aggressive push for educational progress and innovation led to hostility from enough Board of Trustee members and faculty that he resigned in 1892. Adams brought his educational enthusiasm and Thurston's engineering education philosophies with him to Wisconsin. He also noted that by 1893, at the time of his inauguration, Wisconsin had passed beyond its pioneer stage.

Therefore, Adams contended, it was crucial for the state's educational institution to prepare

in 1856. He enrolled at the University of Michigan in 1857 and completed his Bachelor of Arts degree in 1861. He then entered graduate school there, mentored by Andrew D. White, in history. He became an instructor of history in 1862 and replaced White in 1863, becoming a full professor in 1867. After studying in Europe for a year, he returned to Michigan and helped to institute the seminar method of instruction. Though reportedly not a brilliant teacher, he did remain popular with students and his ability to provide executive leadership, and his strong relationship with White, helped him to move on to Cornell University and to become the president of the American Historical Association. After resigning in 1892, he intended to write and do editorial work, but instead accepted the position at the University of Wisconsin. For further details on Adams life and career see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848 to 1925*, Vol. 1 (Madison: University of Wisconsin Press, 1949), 561-579. Adams gave numerous addresses and speeches from the 1870s until his death in 1902. For example see Charles Kendall Adams, "The Relations of Higher Education to National Prosperity." *An Oration delivered before the Phi Beta Kappa Society of the University of Vermont, June 27, 1876* (Burlington: Free Press Print and the Phi Beta Kappa Society, 1875); Charles Kendall Adams, "Higher Education and the State: The Lesson of Colonial Days." Reprinted from the *New Englander* for May, 1878; Charles Kendall Adams, "The Development of Higher Education in America." *Proceedings and Addresses at the Inauguration of Charles Kendall Adams to the Presidency of Cornell University, November 19, 1885* (Syracuse: Press of D. Mason and Co., 1886); and Charles Kendall Adams, "The Morrill Land Grant." *A Memorial Address delivered at the Massachusetts Agricultural College, June 21, 1887* (Amherst: J.E. Williams, Book and Job Printer, 1887). Series 4/8/1/1 M312, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives.

citizens for a modern economy and support the growing infrastructure of transportation, cities, and commercial mining and farming.²⁶

Aggressively emphasizing the land-grant ethos of accessibility, Adams also attempted to promote the benefits of education to all citizens, no matter their class or status. He worked hard to accommodate the expectations of upper class students by offering modern educational practices for undergraduates and graduate students so as to better prepare them for further study and professional success, even if that meant they left Wisconsin to travel east or to Europe. And he encouraged the work ethic of the lower classes by supporting the land-grant philosophy of agricultural and engineering studies, though with the caveat that the programs offer high levels of theoretical knowledge as well as practical preparation for employment through technical workshops that prepared students for the modern engineering and mechanical situations that industry, manufacturing, and business might need. Adams also insisted that in his school's engineering department, faculty should perform productive laboratory research in addition to handling their teaching responsibilities.²⁷

Far from being an ivory tower educator made snobbish by extensive education, the Midwest native Adams personally endeared himself to the working classes by learning about their lives and the culture of Wisconsin. He enjoyed telling the story of a student who supported himself by teaching grammar school during the winter months on the northern end of Lake Mendota. He traveled to and from his schoolroom and the University campus by skating three miles across the lake each day. One March morning, he discovered that the ice

²⁶ Charles Kendall Adams, "The University and the State." *The Addresses at the Inauguration of Charles Kendall Adams, to the Presidency of the University of Wisconsin, January 17, 1893* (Madison: Published by the University, 1893), 11-14, 45-69. Series 4/8/1/1 M312, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives.

²⁷ Charles Kendall Adams, "The University and the State." *The Addresses at the Inauguration of Charles Kendall Adams, to the Presidency of the University of Wisconsin, January 17, 1893* (Madison: Published by the University, 1893), 65-69. Series 4/8/1/1 M312, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives.

had broken and open water blocked the last hundred yards to the northern shore, where his students waited for him. He put his skates in his pocket and swam the remaining distance. Once on shore he pressed the water out of his clothes, walked into his classroom and opened the school on time. Adams loved the industrious nature and work ethic of the farmers, mechanics, and other working class people. And he felt that they gave the institution the kind of regional and national reputation that made the University of Wisconsin a leading national university by the turn of the century.²⁸

Adams also recognized the importance of professional societies and associations. Professionals in every field helped to guide the direction of their fields, whether directly through business models or indirectly through conversations and publications. Though a historian and educator himself, Adams understood the value of scientific, engineering, and technical societies to the current and future development of those fields both in the business world and academia. Adams consistently brought in new ideas for how to improve and promote public education following his attendance at meetings such as the National Teachers Association, American Historical Association, and even the Wisconsin Academy of Sciences, Arts, and Letters. His support of professional growth meant that he provided funding for faculty to join and attend many national meetings during his tenure as president of the University.²⁹

²⁸ Charles Kendall Adams, "The University and the State." *The Addresses at the Inauguration of Charles Kendall Adams, to the Presidency of the University of Wisconsin, January 17, 1893* (Madison: Published by the University, 1893), 15-17, 65. Series 4/8/1/1 M3I2, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives. The story seems to have originated with John Freeman, a University of Wisconsin professor in the 1880s and 1890s. Adams liked it so much he repeated it on several occasions.

²⁹ Charles Kendall Adams, "The University and the State." *The Addresses at the Inauguration of Charles Kendall Adams, to the Presidency of the University of Wisconsin, January 17, 1893* (Madison: Published by the University, 1893), 45-47. Series 4/8/1/1 M3I2, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives. Contained with the department expense reports are lines for "expenses" paid to various faculty members. While not large, these payments did offset the need for dues, journal subscriptions, and travel. For example, see "College Expenses." *University of Wisconsin Biennial Report of the Regents of the*

Immediately upon arriving in Madison, Adams took up the cause of the engineering department. They needed more space, laboratory equipment, and general funding. He justified their needs by noting that the student enrollment in that college nearly equaled all the other colleges combined in 1892, and continued to grow. In 1893, the number of engineering students had grown thirty percent from the previous year and showed every indication of continuing to increase. While the current engineering building and workshops were only eight years old, Adams attributed poor planning and even worse funding to a striking “retardation” of the success of the college. Students numbered 173 in 1893, and the building only safely accommodated 75.

Adams aimed to offer a modern and expansive new building that would handle the needs of the department for at least the next ten to fifteen years. He prefaced his funding request with the knowledge that faculty had had the foresight to design the existing workshop as an expandable building. He asked the Board for funding, about \$11,000 total, to build a new forge room and foundry, as well as a two story addition, in which the electrical engineering faculty could then store their apparatus until the new engineering building was completed. Adams also asked that the science department get new workspace and that new laboratory and workshop equipment be purchased immediately. His total budget request, just for the science and engineering college, amounted to \$33,850.³⁰

The Board enjoyed the prospects of having such a well known educator as their president, but Adams desire to expand and modernize the campus ran head-on into the

University for the Years 1894-95 and 1895-96 (Madison: Democrat Printing Company, State Printer, 1896), 76-78, 91-93. The University of Wisconsin Archives.

³⁰ Charles Kendall Adams, “Needs of the University: Report of President Adams to the Board of Regents.” *The Madison Times*, 6 January 1893: 3-10. The University of Wisconsin Archives. Adams apparently knew about the reluctance of the Board to provide funding. His public request for funding and the needs of the University as an article in the state newspaper of record, rather than a private report to the Board both engaged him with the public and put the Board members on guard. Adams tended to win his battles though, since most of his funding requests during the decade were met.

decades old problem of poor funding at the University of Wisconsin. Luckily, Adams' tenure as president coincided with a significant increase in funding for the University from the land endowment, the state legislature, student fees and tuition, sales from the experiment station, gifts and bequests, and further contributions from the state.³¹

Adams continued to pressure the Board for a new engineering building on behalf of the engineering faculty. He played on the traditional educational philosophies of those who supported classical studies by noting that the engineering program continued to take up space in the science hall, thus robbing those faculty and students of time and space. While engineering student enrollment had leveled off by 1895, at around 200 students, Adams pushed the idea that in order to properly educate modern engineers, faculty and staff needed modern equipment to do cutting edge research. He maintained that modern, professional engineering relied on scientific knowledge more than just practical experience, which meant the University had to extend its reach into materials science, machine design, and laboratory testing. Adams confessed that the college of engineering would remain an increasingly expensive part of the University but defended the cost as worthwhile, given that Wisconsin graduates had already attained leading positions in manufacturing companies, corporations, and went on to train students at many of the top engineering schools in the country. Adams

³¹ Curti and Carstensen provide a very detailed analysis of getting and spending money from 1890 to 1902. See Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848 to 1925*, Vol. 1 (Madison: University of Wisconsin Press, 1949), 580-607. Adams provided detailed income figures for the University in 1898 for the previous two years. Congressional Grants, land sales, and income from the Hatch Act amounted to \$62,990. The state legislature appropriated \$284,873 from a mill tax, building grants, and a railroad tax. And student fees and farm sales amounted to \$109,033. See Charles Kendall Adams, "Report of the President." *Biennial Report of the Regents of the University for the Years 1896-97 and 1897-98* (Madison: Democrat Printing Company, State Printer, 1898), 5-6. The University of Wisconsin Archives.

told the board that the resulting positive effect on the school's reputation alone was worth the "modest expense" of fully supporting the engineering faculty in their work.³²

Adams also used the promise of engineering progress as part of his educational rhetoric aimed at progressive legislators who wanted to build up the state's infrastructure and urban prestige, using technological innovation to highlight Midwestern "newness" as opposed to the "old and crumbling" cities of the east. Adams listed the ways that technical knowledge improved America's living conditions, reminding his audience that engineers provided "incalculable service to the railroad building and maintenance, construction and improvement of highways, the application of electricity to the various forms of lighting and power, and the sanitary improvement of our cities and villages" through water supply and drainage. Adams knew that the perceived reputation and importance of the University in fostering such engineering gains would carry a great deal of weight with legislators.³³

Adams knew how to coordinate information and apply appropriate pressure. Along with scathing addresses on the historical lack of funding at the University, he backed up his statements that the lack of decent space for engineering hampered the sciences by citing reports from the engineering faculty committees, stating that they had completely taken over the science hall, which was inadequate to begin with. Their entire reports in 1894-95 dealt with the need for more space, more equipment, and the inability to do laboratory research which benefited the state, university, and reputation of the faculty.³⁴

³² Charles Kendall Adams, "Report of the President of the University." *University of Wisconsin Biennial Report of the Regents of the University for the Years 1894-95 and 1895-96* (Madison: Democrat Printing Company, State Printer, 1896), 2, 16-17. The University of Wisconsin Archives.

³³ Charles Kendall Adams, "Report of the President of the University." *University of Wisconsin Biennial Report of the Regents of the University for the Years 1894-95 and 1895-96* (Madison: Democrat Printing Company, State Printer, 1896), 17. The University of Wisconsin Archives.

³⁴ Adams did extensive research into the causes and results of funding problems throughout the entire history of the University of Wisconsin in order to support his pronouncements on funding problems. He even went so far as to outline how the University had nearly closed on several occasions because of the "tight-fisted policies of

The faculty also began steering their curriculum and programs away from a balance of classroom, laboratory, and workshop practices. Engineering faculty began emphasizing the importance of laboratory research and theoretical instruction over practical applications. In earlier years, the school's lack of funding support had encouraged faculty to devote substantial class time to student-manufacture of equipment, which not only provided hands-on learning experience but also contributed vital material support for future students.

But as budget prospects became brighter, beginning in 1894, the faculty members became much more vocal about the inadequacy of workshop produced tools and equipment. They admitted that some things might be more cheaply made in the University shops, but contended that hours spent overseeing student labor were a backward use for the mechanical engineering professor's time. Faculty called for support to hire a new shop supervisor, and a well trained mechanic, rather than an engineer, to oversee the construction and repair of the laboratory tools and equipment required for classes and research.

By turning over such routine duties to these staff members, the advocates of change hoped to see faculty devote more time to class work involving increasingly sophisticated theoretical training. This shift in perspective came together with a shift in Wisconsin personnel, as those older university faculty who firmly supported practical training and classroom instruction, such as Storm Bull, D.C. Jackson, and Nelson Whitney, who had been

laggards, idiots, and morons in the state legislature," spending nearly an entire baccalaureate address in 1896 to "inform the student body and enlighten the general public." See, Charles Kendall Adams, "The University and the State." *A Baccalaureate Address by the President of the University, 21 June 1896* (Madison: Published by the University, 1896), 9-25. Series 4/8/1/1 M3I2, Charles Kendall Adams, Addresses, Essays, Etc, Box 1. The University of Wisconsin Archives. For statements by faculty committee members, see Thomas Blackstock, Bevie Clark, and Lucius Fairchild, "Report of the Committee on the College of Engineering," and Henry D. Smith "Committee on School of Mechanics and Engineering." *University of Wisconsin Biennial Report of the Regents of the University for the Years 1894-95 and 1895-96* (Madison: Democrat Printing Company, State Printer, 1896), 39, 60. The University of Wisconsin Archives.

teaching at the University since the early 1880s, gave way to younger faculty members who despised the workshop and considered it beneath their abilities.

D.J. Whittemore, a civil engineering instructor trained at Cornell University, gave a report on the College of Mechanics and Engineering in 1894 that clearly illustrated the new views on engineering education. He made the case for the department to hire a specialized mechanic to handle construction and repair projects, since students “provided wholly unsatisfactory work in the shops.” The students were also “slow and required lots of supervision by a professor of mechanical practice, whose time is needed on institutional work.” In other words, Whittemore wanted the paid shop supervisors to do the construction and repair work that professors asked for, rather than overseeing the practical training of mechanics students. He went on to request over \$150,000 for a new building, lab equipment, and faculty. The total budget of the University in 1896 was only \$403,376, rising to just \$672,408 by 1903. While Board members, Adams, and the faculty made compromises, expansion won out in the end.³⁵

Adams and the engineering faculty got their new building. Wisconsin legislators appropriated \$100,000 for its construction and outfitting beginning in 1896. Adams justified the expenditures for engineering and science by breaking down the backgrounds of students in his 1898 report in order to emphasize their possible business connections, likelihood of future career path, and ability to devote themselves to educational endeavors throughout the year as compared to those who might need to work for a portion of the year to pay their college expenses. Of nearly 1,200 students, 260 came from farms, 231 from merchant families, 90

³⁵ D.J. Whittemore, “Letter on needs of College of Mechanics and Engineering.” Letter dated 15 June 1894. Series 8/1/1, Box 1, Minutes, Engineering Faculty, Faculty Actions, 1890-1905. University of Wisconsin, College of Engineering – Steenbock Library. The totals expenditures for the university were typically published in the *Regents’ Biennial Reports*. Curti and Carstensen also compiled the data in their work. See Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848 to 1925*, Vol. 1 (Madison: University of Wisconsin Press, 1949), 583.

from manufacturing backgrounds and 78 were mechanics, 46 had fathers who worked for railroads, 14 contractors, and eleven had engineers as fathers. Interestingly, Adams and the students made distinctions between mechanics, engineers, railroad workers, and manufacturers by the late 1890s, whereas administrators and faculty did not distinguish these groups in previous decades. Administrators and the public fully recognized the professional distinctions of the working classes as well as the traditional professional groups of clergy, lawyers, and physicians.³⁶

Reflecting the growing size of the school and rising scholastic expectations, Adams and the faculty saw a growing need to separate instruction from administrative oversight by the late 1890s. While Thomas Chamberlain had previously named deans for the College of Law, and the Colleges of Letters and Science, and of Agriculture, the College of Engineering had continued to operate with a committee of faculty through the 1890s. Adams noted in 1898 that “the details of legislation and administrative detail demanded by the several colleges were becoming increasingly burdensome” and a change had to occur immediately. The Regents instructed Adams to name a dean for the engineering college in the summer of 1897, and by 1898 John B. Johnson had accepted the position.³⁷

Johnson brought a fresh perspective and new approach to the College of Engineering. He had taught for several years at Washington University in St. Louis, Missouri before accepting the position in Madison. While he possessed a strong sense of management and engineering acumen, he also pushed for more connections between the engineering

³⁶ Charles Kendall Adams, “Report of the President.” *Biennial Report of the Regents of the University for the Years 1896-97 and 1897-98* (Madison: Democrat Printing Company, State Printer, 1898), 6-7. The University of Wisconsin Archives.

³⁷ For the 1889 and 1991 decisions to name deans to other colleges see Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History, 1848 to 1925*, Vol. 1 (Madison: University of Wisconsin Press, 1949), 443-445. For the Boards request for an Engineering Dean and Adams response see “The College of Engineering.” *Biennial Report of the Regents of the University for the Years 1896-97 and 1897-98* (Madison: Democrat Printing Company, State Printer, 1898), 21-25. The University of Wisconsin Archives.

department and the business community through the school of commerce, which opened in 1900. He noted that the engineering department's current graduation rates could not meet the rapidly growing employment needs of the state, but that the new building would "help alleviate the situation as the public demand continued to increase." Johnson continued to push for more funding within the engineering college, noting that "our engineering graduates have made a reputation for themselves for being eminently practical and efficient and each new supply but increases the demand." Just as Adams had done in 1894 and 1895, Johnson emphasized the good reputation of the University based on professional status and the modern research alumni took part in.³⁸

Johnson pushed his faculty to succeed across the board, in educational, professional, and business worlds. In 1902 he noted that the faculty had published two standard text books and that two more were "nearly complete." He encouraged attendance at professional meetings, again paying for many of the membership dues and travel expenses out of department funds, and happily noted that "a very considerable number of papers, articles, and reviews have been published." The faculty also supervised research in electrolytic compounds related to the corrosion of lead and other metals in the production of paint pigments, led investigations that related to the economy of dynamo construction, and oversaw the materials laboratory investigating concrete and steel construction techniques. Faculty also directed the construction of electrical plants and studied the properties of long distance transmission lines. Engineering faculty and students demonstrated a particular leaning

³⁸ For John B. Johnson's career background see Edward Birge, "Report of the President of the University, Presented by the Acting President." *Biennial Report of the Regents of the University for the Years 1898-99 and 1899-1900* (Madison: Democrat Printing Company, State Printer, 1900), 6, 21-25. The University of Wisconsin Archives.

towards original theoretical research, but they also had their hands in practical applications and industry as well.³⁹

Already by the 1890s, Wisconsin businessmen and industrialists supported and benefited from the large engineering department at the University. While agriculture continued to lead all industries in the state at the end of the nineteenth century, industrialists and financiers capitalized on the location and resources of the state to expand manufacturing. Most of the lumber companies in the state had consolidated into corporations by 1896, allowing for the purchase, and accompanying maintenance and repair, of milling and transportation machinery. Businessmen also opened aluminum, steel, and rubber production factories in the 1890s and successfully made profits by the early 1900s. The growth of larger factories to accommodate the various industries coincided with a switch from water and steam powered factories to electrical power. In the southeast corner of the state, manufacturers who had focused on flour milling, iron smelting, and tanning before 1880, switched to the production of finished products. E.P. Allis formed the Allis-Chalmers company in the late 1880s, producing agricultural implements, wagons, steam engines, and machine tools. Their Reynolds-Corliss engine powered the entire 1893 World's Columbian Exposition from Machinery Hall.⁴⁰

Engineering students from the University benefited in numerous ways. The mechanical students who focused on shop and foundry work entered the growing steel

³⁹ Edward Birge, "Report of the President of the University, Presented by the Acting President." *Biennial Report of the Regents of the University for the Years 1900-01 and 1901-02* (Madison: Democrat Printing Company, State Printer, 1902), 18-22. Numerous other projects continued in the following years. See F. E. Turneure, "Report of the Dean of the College of Engineering." *Biennial Report of the Regents of the University for the Years 1902-3 and 1903-4* (Madison: Democrat Printing Company, State Printer, 1904), 102-114. The University of Wisconsin Archives.

⁴⁰ John D. Buenker, *The History of Wisconsin, The Progressive Era, 1893-1914* (Madison: State Historical Society of Wisconsin, 1998), 80-125. See also, Robert C. Nesbit, *Wisconsin, A History* (Madison: The State Historical Society of Wisconsin, 1973), 313-335; William Francis Raney, *Wisconsin, A Story of Progress* (New York: Prentice-Hall, Inc., 1940), 328-341.

industry, which relied on foundries and machine shops. Civil engineering students quickly found employment in the state's rapidly expanding transportation industries, including railroad and steamship companies that needed new rail lines surveyed and harbors improved. Mechanical engineers often had trouble completing their entire degree coursework in the 1880s and 1890s. These students often worked during vacations for manufacturers, railroad companies, or implement and machine tool factories, which led to more permanent jobs that pulled them away from their University training in favor of a paid job.⁴¹

However, other students had more success finishing their degrees and then finding jobs. Electrical engineers from the University soon took leadership positions at the new electrical companies, and mining engineers improved the production and distribution of ores from the northern portions of the state. Chamberlain and Adams, along with the engineering faculty maintained the workshops and foundry as part of the engineering college simply because those technically trained students were in demand across the state. The faculty supported the growth of industry, especially in the areas around Madison and to the south, by providing research and trained graduates for the new industries that emerged in the 1890s and 1900s.⁴²

Johnson succeeded in carrying the engineering department into the twentieth century. He led a staff of nearly twenty professors and shop supervisors, including Storm Bull, D.C. Jackson, and Nelson Whitney who brought over twenty years of educational experience to the

⁴¹ John D. Buenker, *The History of Wisconsin, The Progressive Era, 1893-1914* (Madison: State Historical Society of Wisconsin, 1998), 80-125, 375-381. The connections between growing industries and alumni were often highlighted in the *Regent's Biennial Report* by either the president or the engineering dean. For example, see F. E. Turneure, "Report of the Dean of the College of Engineering." *Biennial Report of the Regents of the University for the Years 1902-3 and 1903-4* (Madison: Democrat Printing Company, State Printer, 1904), 102-114. The University of Wisconsin Archives.

⁴² John D. Buenker, *The History of Wisconsin, The Progressive Era, 1893-1914* (Madison: State Historical Society of Wisconsin, 1998), 80-125, 375-381; and F. E. Turneure, "Report of the Dean of the College of Engineering." *Biennial Report of the Regents of the University for the Years 1902-3 and 1903-4* (Madison: Democrat Printing Company, State Printer, 1904), 102-114. The University of Wisconsin Archives.

college. Many of the other professors, while not of great fame, provided many years of quality instruction and public service through the University. Johnson successfully acquired another \$5,000 in 1900 and another \$30,000 in 1902 to equip and furnish the new engineering building, despite the firm statements by the legislature that the original \$100,000 had to account for all building and equipment needs.⁴³

Johnson presided over one of the largest increases in student enrollment for the college of engineering. While the department averaged anywhere from 140 to 180 students between 1889 and 1896, 242 students enrolled in 1898 and that number had increased to 513 by 1901, over 600 by 1902, and past 800 by 1904. Johnson proudly proclaimed that “a large proportion of our students find employment in their profession,” pointing out that the U.S. Geological Survey and Lake Surveys hired many of the newly minted engineers, and even juniors had taken charge of “a difficult railway construction project involving tunneling and bridge work.” While the faculty increasingly stressed research and distinguished between their specialized research and the practical work in the shops, Johnson took every opportunity to showcase the advantages and successes of what he considered a “modern” engineering department.⁴⁴

The Iowa State College of Agricultural and Mechanic Arts

By the early 1890s, Iowa’s engineering faculty saw a bright future. In 1891, seventy-eight students enrolled in the engineering programs. Faculty offered civil, mechanical,

⁴³ The list of faculty in 1900 consisted of John B. Johnson, Storm Bull, Dugald Jackson, Nelson Whitney, Charles Wing, Fredrick Turneaure, Edward R. Maurer, Arthur W. Richter, S. B. Fortenburgh, Charles King, J.E. Davis, L.S. Smith, and Jonathan G. Mack. This list was compiled by reviewing the expenditure list for the Engineering College between 1870 and 1900 in the *Regent’s Biennial Reports*.

⁴⁴ For the report on enrollment, activities, and accomplishments of the College of Engineering see Edward Birge, “Report of the President of the University, Presented by the Acting President.” *Biennial Report of the Regents of the University for the Years 1900-01 and 1901-02* (Madison: Democrat Printing Company, State Printer, 1902), 18-23. The University of Wisconsin Archives.

electrical and mining engineering studies, as well as continuing to require workshop hours. When college president William Beardshear appointed George Bissell, Anson Marston, and William Franklin as heads of their departments, mechanical, civil, and electrical engineering respectively, they began to oversee a long and expansive period for engineering at the Iowa Agricultural College.⁴⁵

William Beardshear presided over the Iowa Agricultural College for ten prosperous and progressive years. He exemplified the spirit of western utilitarian idealism by focusing on the practical aspects of education and the needs of farmers and manufacturers while maintaining strong support for theoretical scientific instruction in physics, chemistry, and biology. He had spent most of his adult life in Iowa, and after several years in the ministry, he became the head of the Des Moines school district. This experience allowed Beardshear to maneuver the Agricultural College into a better position with regards to technical and agricultural instruction in relation to the rest of the public education system in Iowa. His approach meant a significant expansion in instructors, research, and practical training.⁴⁶

During the 1890s, the Iowa Agricultural College had one of the largest engineering staffs in the Midwest. In 1892, five professors and four instructors covered the engineering and workshop curriculum. James Lincoln, a Confederate veteran and director of military science at the Agricultural College since 1883, took over the new mining engineering program. William Franklin, native of Kansas and recipient of numerous academic honors from the University of Berlin and Harvard, came to Iowa to teach physics but spent most of his career directing the electrical engineering program. George Bissell graduated from

⁴⁵ Earle D. Ross, *A History of Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 205-207. For a more impressionistic account of the faculty see *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 221-254.

⁴⁶ Earle D. Ross, *A History of Iowa State College of Agriculture and Mechanic Arts* (Ames: The Iowa State College Press, 1942), 202-207.

Cornell University with a mechanical engineering degree in 1888 and spent three years as an instructor in experimental engineering at Sibley College before coming to Iowa to run the mechanical engineering program. Warren Meeker also graduated from Cornell with a mechanical engineering degree in 1891 and came directly to Iowa to assist Charles Scribner and work alongside his college classmate Bissell.⁴⁷

Anson Marston graduated from Cornell University in 1888. He spent three years working for the Missouri Pacific Railway in Louisiana, designing and overseeing the construction of steel bridges for the company. He became the professor of civil engineering at the Iowa Agricultural College in 1892, and the dean of the engineering department in 1893. Like his counterparts at Wisconsin and Michigan, Marston made it a point among his faculty to promote membership in and attendance at national engineering societies. He remained an active member of the Society for Promoting Engineering Education and the American Society of Civil Engineers throughout his career in Iowa. Reflecting the late nineteenth-century's sense of the increasing importance of professional organizations, Marston also began an Engineering Society for undergraduate students at the Agricultural College so that he could offer them a more professional outlet for their laboratory and field research. He also published numerous articles on civil engineering, water and sewerage planning, and engineering education in the 1900s and 1910s.⁴⁸

To support the practical training side of the curriculum, which continued to include heavy requirements for student shop work, the engineering faculty had several assistants through the 1890s as well. Frederick Harris, from 1892 to 1893, and then Talbot Lennox,

⁴⁷ *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 237.

⁴⁸ *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 237-238.

1893 to 1906, both local mechanics from Ames, supervised the machine shop. Henry Nordstrum, from 1892 to 1896, and then Ezra Potter, from 1897 to the 1910s, both journeymen carpenters who had traveled the country, instructed students in the carpentry shop and helped with many of the campus building projects that involved framing and furniture making. William Clark and Alan Horter, both from central Iowa farms, managed the forge and blacksmith shop for the college.⁴⁹

The faculty developed a demanding curriculum for their programs. Besides classes in English, history, and Rhetoric, freshmen took advanced algebra, geometry, drawing, and eight hours of shop work every semester. Sophomores had classes in physics, chemistry, trigonometry, analytical geometry, and more hours of shop work. Juniors in mechanical engineering took calculus, mechanics, materials construction, and spent three to four hours in the laboratory. Senior mechanical engineering majors had specialized courses in machine design, steam engines, thermodynamics, shop work, and laboratory research leading to a senior thesis. Students in civil engineering had courses and field work in materials construction, sanitary engineering, and hydraulic engineering. Electrical engineering majors had specialized coursework in electricity and magnetism, machine design and materials construction, and spent three to five hours a semester in the mechanical shops and laboratories. Students in the mining engineering program had classes in mineralogy, mining, metallurgy, tunneling, electricity and magnetism, economics, and laboratory research leading to senior thesis.⁵⁰

⁴⁹ "Office of Instruction." *Iowa State College of Agriculture and Mechanic Arts Catalogue 1892* (Ames: The College, 1892), 8-9. See also, *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 221-254. Iowa State University Archives/Special Collections.

⁵⁰ "The Course in Mechanical Engineering, Civil Engineering, Electrical Engineering, and Mining Engineering." *Iowa State College of Agriculture and Mechanic Arts Catalogue 1892* (Ames: The College, 1892), 26-30. Iowa State University Archives/Special Collections. Faculty descriptions of their coursework and the program requirements followed the curriculum.

The new faculty members demanded both breadth and depth in the engineering curriculum, resulting in what they liked to describe as “professional engineers well versed in theory, familiarized with ordinary engineering processes, and capable of the highest achievements of great engineers.” Faculty members, particularly those from Cornell, focused approximately two-thirds of the curriculum on theory and classroom study. Students’ remaining time was spent in the various workshops as underclassmen, and in the research laboratories or doing field work as juniors and seniors. Beardshear appropriated over \$35,000 for the faculty to update and equip their laboratories and the workshops in 1891, and the faculty put the money to good use by buying modern equipment for their laboratories, such as meters for measuring material strength and more accurate gauges for steam engine power, along with multi-use machinery and hand tools for the shops.⁵¹

Beardshear also began improving the practical training facilities of the campus early in his tenure. In 1893, he noted that the forge, carpentry, and forge shops were “a sorry excuse for a structure,” and “quite antiquated, deficient and inefficient.” He requested \$24,000 from the Board for a new forge and foundry, carpenter and manual training shop, and a new machine shop. He increased this amount to \$32,000 two years later. He also supported numerous other departments and projects on campus, requesting a total of \$186,750 for a magnetic observatory, green houses, experiment barn, astronomical laboratory, and armory among other things. Beardshear wanted to expand the campus and offer as many programs as

⁵¹ G.W. Bissell, “The Course in Mechanical Engineering.”; A. Marston, “The Course in Civil Engineering.”; W.S. Franklin, “The Course in Civil Engineering.”; and J.R. Lincoln, “The Course in Mining Engineering.” *Iowa State College of Agriculture and Mechanic Arts Catalogue 1892* (Ames: The College, 1892), 39-47. Iowa State University Archives/Special Collections. Bissell and Marston gave more explicit descriptions of the equipment they had purchased in the 1892 *Biennial Report*. See G.W. Bissell, “Mechanical Engineering,” and A. Marston, “Civil Engineering.” *Fifteenth Biennial Report of the Board of Trustees of the Iowa State Agricultural College and Farm for the Years 1892 to 1893* (Des Moines: G.H. Ragsdale, State Printer, 1893), 58-62. Iowa State University Archives/Special Collections.

possible for the growing population of the state, particularly in the traditional land-grant specialties of engineering, science, and agriculture.⁵²

The engineering faculty assisted Beardshear in his promotion of the Agricultural College by reworking their course descriptions to emphasize the breadth of preparation and new opportunities for specializing and pre-employment training. Bissell and Marston began a change in terminology by the mid-1890s to promote the professional status of their programs, and entice more students to the Agricultural College. They changed “practical and workshop training” to “professional work.” Students still did the same activities; drawing, surveying, leveling, and forge and woodshop work. But the new classification also included railroad engineering, mechanics and hydraulics, laboratory work, construction methods, and the senior thesis research project. James Lincoln began introducing more commercial law and bookkeeping studies into his mining engineering curriculum to better prepare graduates for business management.⁵³

More faculty members arrived in Ames by the mid-1890s to assist with the engineering curriculum as well. While Franklin, Bissell, and Marston continued to direct the programs, they also strove to add positions for more full time professors instead of just instructors. Louis Spinney, an 1893 graduate of the Agricultural College, returned to assist with physics and mechanical engineering, after having completed post-graduate work at

⁵² William Beardshear, “Report of the President.” *Fifteenth Biennial Report of the Board of Trustees of the Iowa State Agricultural College and Farm for the Years 1892 to 1893* (Des Moines: G.H. Ragsdale, State Printer, 1893), 5-17. Iowa State University Archives/Special Collections. On the growth of Iowa, see Joseph Frazier Wall, *Iowa: A Bicentennial History* (W.W. Norton & Company, 1978), 145. For the increase in funding requests in 1894 see William Beardshear, “President’s Report.” *Sixteenth Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm for the Years 1894 and 1895* (Des Moines: F.R. Conaway, State Printers, 1895), 4-13. Iowa State University Archives/Special Collections.

⁵³ G.W. Bissell, “Department of Mechanical Engineering.”; A. Marston, “Civil Engineering.”; and James Rush Lincoln, “Mining Engineering.” *Sixteenth Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm for the Years 1894 and 1895* (Des Moines: F.R. Conaway, State Printers, 1895), 51-59. Iowa State University Archives/Special Collections.

Cornell University, the University of Berlin, and the Polytechnikum in Zurich, Switzerland. Elimina Wilson, a graduate of the civil engineering program at the Agricultural College, with graduate engineering work completed at Cornell and the Massachusetts Institute of Technology, became one of the first female assistant professors at the institution outside the area of home economics and other courses targeted to women students. She primarily oversaw the mechanical and civil engineering drawing courses, but also assisted in the laboratories. Samuel Beyer, an 1889 graduate with graduate work in geology and coursework from Johns Hopkins, became an assistant professor in the mining engineering program.⁵⁴

These new faculty, who often combined an initial degree from Iowa with advanced laboratory training from east coast and European schools, continued the school's mid-1890s tendency to stress more specialized training and research. Bissell and Marston brought a sharp focus on employability, focusing a student's education on "study which will most benefit him in later work." Freshmen and sophomore students still spent eight to ten hours a week in the workshops, but the research conducted by upperclassmen became much more specialized. Bissell proudly noted that student work included experiments in tensile strength, compression tests of materials, proprieties of lubricants, power absorption and transmission of dynamometers, cement testing, and efficiency tests of steam engines, just to name a few. Marston began including applied mathematics as part of the instructional curriculum and required students to perform surveying projects for local railroads and city governments. His

⁵⁴ "Officers of Instruction." *Iowa State College of Agriculture and Mechanic Arts Catalogue 1894-1895* (Ames: By the College, 1894), 2-4. Iowa State University Archives/Special Collections. More detailed information on the background of the instructors is located in *History and Reminiscences of I.A.C.* (Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897), 235-254.

laboratory work focused on cement testing and by the 1910s and 1920s he had specialized in road construction, an extremely valuable specialty for a nation entering the automobile age.⁵⁵

As a result of such ambitious expansion, the engineering programs outgrew their 1891 building within five years. In 1897, Beardshear again had to request a hefty, \$75,000 appropriation in order to accommodate the expanding enrollment and research projects of the engineering departments. He included another \$10,000 for machine shops. Marston also submitted his proposal of \$34,000 for the campus water system and a new water tower, which the Board of Regents had contracted him to design in 1893. Indeed, the growth of the entire campus meant that faculty and students across campus were struggling with a lack of space, requiring a tremendous amount of construction and campus expansion during the 1890s.⁵⁶

By the end of the 1890s, the engineering faculty numbered thirteen. Professors directed four distinct colleges of engineering; mechanical, civil, electrical, and mining engineering. Students could also take specialized courses in steam engineering or irrigation engineering. The engineering departments graduated 340 students in 1900; 81 in mechanical engineering, 74 in civil engineering, 164 in electrical engineering, and 21 in mining engineering. In terms of sheer size, these numbers made Iowa one of the biggest contributors to America's next generation of engineers. The only schools that graduated more engineers that year were the Massachusetts Institute of Technology with 356 and Cornell University with 945. Industrial growth necessitated most of the growth in the Midwest and Plains states.

⁵⁵ Anson Marston, "The Course in Mechanics and Civil Engineering." *Iowa State College of Agriculture and Mechanic Arts Catalogue 1894-1895* (Ames: By the College, 1894), 44-49. Iowa State University Archives/Special Collections. Marston's experimental work and publications are included in Herbert J. Gilkey, *Anson Marston: Iowa State University's First Dean of Engineering* (Ames: Iowa State University College of Engineering, 1968), 85-260.

⁵⁶ William Beardshear, "President's Report." and Anson Marston, "Engineers Report on Waterworks." *Seventeenth Biennial Report of the Board of Trustees of the Iowa Agricultural College and Farm for the Years 1896 and 1897* (Des Moines: F.R. Conaway, State Printers, 1897), 1-48. Iowa State University Archives/Special Collections.

The students came from rapidly growing cities and also from farms which had become more mechanized.⁵⁷

The engineering faculty and students began a new era in 1903. They moved into their new engineering building on the west side of campus, a four story structure built to house all the engineering classes, the laboratories, and allow room for expansion. For the price of \$150,000, a \$50,000 increase over Beardshear's requests three years earlier, the faculty proudly proclaimed that they could finally get out from under the thumb of the science faculty and the restrictions they placed on research space. Marston also requested \$15,000 a year to organize and run an Engineering Experiment Station, which he regarded as essential to link the school's research expertise to the economic needs of nearby business and the state. Within a year, he had the station up and running. Station researchers contributed a great deal too state road projects, steam generation from Iowa coal, hydraulic dredging, sewage disposal, and dry brick testing.⁵⁸

Administrators and faculty also began taking greater notice of Iowa's manufacturing and industrial situation during the 1890s, specifically with regard to growing employment

⁵⁷ "Faculty-Division of Engineering." *Iowa State College of Agriculture and the Mechanic Arts Catalogue 1898-99* (Ames: By the College, 1899), 100-101. Iowa State University Archives/Special Collections. The statistics for engineering graduates was compiled from data in the *Report of the Commissioner of Education Made to the Secretary of the Interior for 1899-1900* (Washington: Government Printing office 1900), 55-60. On the changing dynamics of farm and industrial workers in the Midwest, as well as the revolutions in production and work that workers had to adjust to see Daniel Nelson, *Farm and Factory, Workers in the Midwest 1880-1990* (Bloomington: Indiana University Press, 1995).

⁵⁸ The final request for a new engineering building before it was actually built came from Beardshear in 1899, accompanied by supporting statements from the directors of the engineering departments. See William Beardshear, "President's Report." *Eighteenth Biennial Report of the Iowa State College of Agriculture and the Mechanic Arts for the Years 1898-99* (Des Moines: F.R. Conaway, State Printer, 1899), 7-8. Iowa State University Archives/Special Collections. On student enrollment and the specific engineering numbers, road experimentation, and Marston's request for an engineering experiment station see Albert Storms, "President's Report." *Twentieth Biennial Report of the Iowa State College of Agriculture and the Mechanic Arts for the Years 1902-1903* (Des Moines: F.R. Conaway, State Printer, 1903), 8, 26-29, 47-49. Iowa State University Archives/Special Collections. Specific experiments done at the Experiment Station were listed in 1905 for the first time. See Albert Storms, "President's Report." *Twenty-First Biennial Report of the Iowa State College of Agriculture and the Mechanic Arts for the Years 1903-1905* (Des Moines: B. Murphy, State Printer, 1906), 11. Iowa State University Archives/Special Collections.

opportunities for local college-educated engineers. While railroads continued to dominate the transportation industry, they also supported the expansion of coal mining, stone quarrying, and cement production. Mining businessmen produced \$15,000,000 worth of raw materials in the years between 1895 and 1902, including coal, granite, and limestone. Railroads employed 38,000 people, while manufacturing as a whole employed over 58,000. While Iowa agriculture remained strong, the expansion of manufacturing added diversity to the state's economic base.⁵⁹

By 1900, Agricultural College administrators and engineering faculty reported that manufacturing industries produced \$164,618,000 worth of goods, compared to \$365,412,000 worth of production from farms. Administrators and faculty at the Agricultural College benefited from a markedly improved industrial situation, necessitating better trained engineers and mechanics. And many of the graduates now found employment within Iowa, rather than moving east to established companies, or traveling west to work with new industries. Modernization of Iowa's infrastructure generated further demands for in-state engineering expertise. By the early 1900s, town residents began purchasing more automobiles, necessitating new roads, bridges, and water drainage which the Engineering Experiment Station quickly took the lead in designing.⁶⁰

⁵⁹ Albert Storms provided a detailed analysis of Iowa manufacturing and labor in his 1903 report to the Board. He also provided a detailed list of projects the engineering faculty worked on in connection with the state's industries. See Albert Storms, "President's Report." *Twentieth Biennial Report of the Iowa State College of Agriculture and the Mechanic Arts for the Years 1902-1903* (Des Moines: F.R. Conaway, State Printer, 1903), 30-31. Iowa State University Archives/Special Collections.

⁶⁰ Albert Storms, "President's Report." *Twentieth Biennial Report of the Iowa State College of Agriculture and the Mechanic Arts for the Years 1902-1903* (Des Moines: F.R. Conaway, State Printer, 1903), 30-31. Iowa State University Archives/Special Collections. Iowa historians have produced surprisingly poor histories of the state, especially compared to other Midwestern and Plains states. Though it contains very few statistics and little on manufacturing and business, other than the state's early coal industry, see Dorothy Schweider, *Iowa, The Middle Land* (Ames: Iowa State University Press, 1996), 160-161.

Engineering education at the Iowa Agricultural College provided a model for the rest of the nation. Graduates who had helped Marston and his staff with the road experiments moved to surrounding states, and engineering faculty traveled to Ames to consult with Marston and to attend national engineering society conferences. Students benefited from the forward thinking of administrators and faculty who were able to expand the engineering program into one of the country's biggest producers of graduates, while maintaining an educational philosophy that combined classroom instruction, workshop training, and by the 1890s, laboratory research. The size of the engineering enrollment by the turn of the century testified to the popularity of the programs. And the administration's and faculty's commitment to supporting Iowa's manufacturers and industrialists stretched to new heights after the turn of the century with the help of the engineering station and professors who focused their research on road-building, coal mining, and similar practical problems of the state.⁶¹

The University of Nebraska - Lincoln

In sharp contrast to the strong programs that had emerged in Iowa, Wisconsin, and Michigan, the professionalization of engineers and engineering education remained a lackluster pursuit in Nebraska by the mid-1890s. Charles Bessey and James Canfield had done much to improve technical education at the University of Nebraska by 1893, but faculty disagreements, conflicting educational philosophies, and a dearth of manufacturing or engineering jobs in the state meant that mechanic arts education in the state remained

⁶¹ The work of civil engineering and the engineering departments in the first half of the twentieth-century have been examined in several previous works. See Almon H. Fuller, *A History of Civil Engineering at Iowa State College* (Ames: Iowa State University, 1959); Henry Black and Stanley Ring, *IES One Hundred: A History of the Iowa Engineering Society, 1889-1989* (Des Moines: The Iowa Engineering Society, 1989); and James Baker Ross, "Engineering Education at Iowa State College of Agriculture and Mechanic Arts, 1906-1920," (Master's Thesis, Iowa State University, 1978).

secondary to other pursuits. However, by the turn of the century, administration and faculty changes and professional and public pressure slowly began to change the circumstances for engineers even in Nebraska.

Charles Bessey continued to develop and promote the Industrial College throughout the 1890s. In his 1893 report to the Regents, Bessey noted that he continued to encourage “broad and thorough and at the same time practical” education for the students. Relying on his years of experience and the educational philosophy that he developed while a student at the Michigan Agricultural College and as a professor at the Iowa Agricultural College, Bessey wanted to make sure that students could easily adapt the coursework and practical skill training that the Industrial College provided to the “work of life and yet retain culture and discipline.” But Bessey aimed to make the science, agricultural, and engineering departments a much more significant part of the University.⁶²

Bessey began his campaign to enlarge and improve the Industrial College with big plans. In 1893, he began the process of asking for funds to build a new manual training and engineering building. He organized the entire engineering department around the mechanical engineering curriculum. Students then branched out into manual training courses, civil and irrigation engineering, and electrical engineering. Writing to the regents, Bessey pointed out that Nebraska’s land-grant counterparts in other states had already made substantial commitments to modernize and expand engineering education. He noted that administrators had already approved new engineering buildings at Illinois University and Sibley College at Cornell University, and that the curriculum used by the University of Wisconsin had the best arrangement for the “unification of the work in engineering.” Bessey played on the Board’s

⁶² Charles Bessey, “Semi-Annual Report to the Board of Regents.” Typed manuscript dated 12/20/1893. RG 01/01/01, Charles Bessey Papers, Box 11, Folder 88. University Archives / Special Collections – University of Nebraska-Lincoln.

long standing desire to have a nationally recognized university, and he organized his improvements based on other schools of national repute.⁶³

Like other land-grant schools, Nebraska witnessed significant increases in enrollment during the 1890s, but faculty and administrators were concerned that poor or inconsistent preparation created a distinct disadvantage for students coming from rural schools and farms. In 1895, the Board of Regents proposed to open a School of Agriculture and Mechanic Arts, a kind of land-grant high school, that would allow “eighty-percent of the school age children” to get a better education. The Board actually hoped to fully eliminate the Latin School and cut the number of technical students at the University, thereby undercutting the dominance of the Industrial College, essentially making it and its programs little more than a high school, and elevating the status of the humanities departments. They designed the new agricultural and mechanic arts school as a three year, short-course program which farm and mechanics students could use to avoid the bulk of the humanities curriculum. This also opened up more seats for students in the English, classics, Literature, and modern languages. This school would allow the Regents to maintain the land-grant status of the University, while diminishing the “agricultural and mechanic arts” portion of the Act’s mandate. While the Regents had hoped to improve the status of classical studies at the University, their plan actually boosted the number of scientific and technical students by providing a dedicated program of study that funneled new students into the University’s Industrial College.⁶⁴

The Board had already orchestrated specialization and an emphasis on pure science in chemistry and biology that limited the offerings of the Industrial College. In 1894, the

⁶³ Charles Bessey, “Semi-Annual Report to the Board of Regents.” Typed manuscript dated 12/20/1893. RG 01/01/01, Charles Bessey Papers, Box 11, Folder 88. University Archives / Special Collections – University of Nebraska-Lincoln.

⁶⁴ “The Proposed School of Agriculture and Mechanic Arts.” *The University of Nebraska Twelfth Biennial Report of the Board of Regents* (Lincoln: Published by the University, 1894), 15. RG 01/05, Box 2, Folder 3. University Archives / Special Collection – University of Nebraska-Lincoln.

University had ten chemistry instructors, seven mathematics professors, one professor of agriculture, one professor of botany, four physics instructors, and one professor each in electrical engineering, civil engineering, and machine design and mechanical drawing.

Charles Ingersoll, an 1877 graduate of the Michigan Agricultural College, had also become the new dean of the Industrial College, which meant the plans Charles Bessey had begun the previous year had to be reviewed by new administrators and languished in committee meetings with the Board.⁶⁵

The faculty limitations meant that Nebraska engineering students had significantly more restricted opportunities for specialized training than did their counterparts studying at Iowa, Wisconsin, or Michigan. Even though Bessey had based his engineering curriculum plan on the mechanical engineering program used at Iowa's Agricultural College, the University of Nebraska only offered degrees in civil and electrical engineering in 1894 due to a lack of qualified faculty. Since only three faculty members had training even in these fields, the mathematics and physics instructors had to open up their curriculum to accommodate these students as juniors and seniors. Civil engineering students had specialized courses in graphics, surveying, railroad engineering, bridge and materials construction (now known as materials science), water supply and sewerage, and completion of senior project-thesis. Electrical engineering students, which included steam engineering, took courses in applied electricity and measurements, principles of electrical installation, mathematical theory of electricity and magnetism, applied mechanics and mechanisms, machine design and mechanical drawing, steam engineering, and theory of prime movers. Any student interested in mechanical engineering had to split his time between steam engineering and electrical

⁶⁵ "Members of the Senate and Other Instructors." *University of Nebraska Catalogue, 1894* (Lincoln: Published by the University, 1894), 6-12. RG 00/07 Bulletins and Catalogues, Box 3, Folder 1. University Archives / Special Collections – University of Nebraska-Lincoln.

engineering, with basically no time left for shop or laboratory training. Engineering students trained at the University of Nebraska found themselves at a distinct disadvantage compared with their land-grant cohorts.⁶⁶

The faculty tensions also remained well entrenched by the mid-1890s. Replying to a request from De Witt Brace, the chair of the physics department, for more physics instructors, Hudson Nicholson, the chair of the chemistry department, noted that “anyone with experience teaching both chemistry and physics will say without hesitation that it requires twice as much time and labor to handle the chemistry class.” Both Brace and Nicholson had been at the University since the 1880s, Brace with degrees from Boston University and the University of Berlin, and Nicholson from Lawrence Scientific School at Harvard. They used the science departments as their personal fiefdoms, while professors in the Industrial College continued to struggle educating and training the agricultural and engineering students.⁶⁷

Interestingly, the mathematics faculty provided one of the few positive developments for engineering training at Nebraska in the 1890s. Ellery Davis, a graduate of the University of Wisconsin and Johns Hopkins, and T. Morey Hodgman, from Rochester University, along with six additional instructors, provided a mathematics curriculum that rivaled any on the east coast. By 1895, they required all freshmen and sophomores to take courses in trigonometry, higher algebra, conic sections, and analytic geometry. Students who majored in mathematics,

⁶⁶ “Departments of Instruction.” *Courses of Study at the University of Nebraska* (Lincoln: Published by the University, 1893), 12-13. RG 00/07 Bulletins and Catalogues, Box 3, Folder 2. University Archives / Special Collections – University of Nebraska-Lincoln.

⁶⁷ Nicholson quoted the higher numbers of chemistry professors compared to physics professors at Michigan, Minnesota, Cornell, Purdue, Iowa, California, Wisconsin, Virginia, Yale, and Harvard. This was an interesting mix of land-grant, state, and east coast schools, few of which were known as engineering schools. But Nicholson was able to show that certain schools did have about twice as many chemistry instructors as chemistry. H.H. Nicholson letter to Chancellor Canfield dated 1884. RG 01/01/01, Box 11, Folder 86. University Archives / Special Collections – University of Nebraska-Lincoln. The background and tenure of specific professors was listed in the yearly catalogues. Nicholson came to the University in 1882 and Brace arrived in 1888. See “Members of the Senate and Other Instructors.” *University of Nebraska Catalogue, 1894* (Lincoln: Published by the University, 1894), 6-12. RG 00/07 Bulletins and Catalogues, Box 3, Folder 1. University Archives / Special Collections – University of Nebraska-Lincoln.

sciences, or engineering had the option to take calculus, differential equations, three dimensional geometry, analytical statics, and determinants. In fact, civil and electrical engineering students filled an entire section of higher algebra and analytical geometry every spring semester.⁶⁸

By 1893, the engineering faculty had fully transitioned to new staff members. Charles Little ended his ten year tenure as the civil engineering professor and Oscar Stout, one of his students, took over the curriculum. Robert Owens, a graduate of Columbia and Johns Hopkins, took over the electrical engineering courses that year. Charles Richards and W.B Hampson, both new graduates of Purdue University with degrees in mechanical engineering, assisted with manual training, graphics, machine design, and mechanical drawing. With these new hires, Chancellor Canfield, Dean Ingersoll, and the Board managed to assemble a mixture of east coast and land-grant talent to oversee the small engineering curriculum.⁶⁹

Despite the faculty disagreements and limitations in technical skill training, the engineering faculty did manage to slowly expand their curriculum. The increase in students enrolling in the Industrial College helped their cause immensely. In 1890, just 488 total students enrolled in the University, with 130 of them in the Industrial College. By 1893, there were 1000 students, with over 500 in the Industrial College. By 1895, 1550 students enrolled in the University with nearly 800 students completing coursework in the agricultural and engineering departments. Dean Ingersoll, with the guidance of Charles Bessey, hired George Chatburn, an 1884 graduate of the Iowa Agricultural College, to assist with mathematics and civil engineering courses, bringing the total engineering faculty up to five. Ingersoll also

⁶⁸ “Departments of Instruction.” *University of Nebraska Courses of Study, 1894-1895* (Lincoln: Published by the University, 1894), 22. RG 00/07 Bulletins and Catalogues, Box 3, Folder 2. University Archives / Special Collections – University of Nebraska-Lincoln.

⁶⁹ “Members of the Senate and Other Instructors.” *University of Nebraska Catalogue, 1895* (Lincoln: Published by the University, 1895), 6-9. RG 00/07, Bulletins and Catalogues, Box 3, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

bumped the mathematics faculty up to nine, and renewed the funding requests for a new engineering, science, and mathematics building.⁷⁰

George MacLean, a professor of English from the University of Minnesota, entered as Chancellor in 1895, following the resignation of James Canfield. MacLean brought a strong conviction that the primary mission of land-grant institutions was to combine technical training with traditional academic coursework. He supported the establishment of secondary technological schools in agriculture, dairying, and mechanic arts, so that the student enrollment in those fundamental land-grant university components could increase. Though the students never warmed to MacLean's "quality over quantity" message, MacLean did continue Canfield's financial support of technical departments and helped Ingersoll and Bessey expand the scientific and technical offerings in the Industrial College.⁷¹

Faculty improved the engineering curriculum in a number of ways after 1895. In addition to the standard curriculum students had taken for numerous years, the faculty began providing more practical and laboratory experience. Students performed more surveying drills using levels, transits, and solar attachments. They conducted both urban and rural surveying, railroad line route mapping, excavation and embankment measurements, and began taking courses in the "theory of economic location with reference to probable traffic, cost of operation, and maintenance." The younger faculty aimed to produce graduates that

⁷⁰ "The Faculty." *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 67-69. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln. University statistics for student enrollment usually appeared in the yearly Catalogue. See *University of Nebraska Catalogue, 1895* (Lincoln: Published by the University, 1895), 6-9. RG 00/07, Bulletins and Catalogues, Box 3, Folder 3. University Archives / Special Collections – University of Nebraska-Lincoln.

⁷¹ Robert N. Manley, *Centennial History of the University of Nebraska, Vol. I. Frontier University, 1869-1919* (Lincoln: University of Nebraska Press, 1969), 116-117.

had experience with city planning to take jobs in and provide technical leadership for the rapidly growing industrial and urban centers of the Midwest.⁷²

The engineering faculty also expanded the mechanical and electrical courses, finally beginning to match the curriculum options offered at other land-grant schools. Students in materials science courses now studied stress and strain of metals, strength of concrete and stone, shafting, plating, and rivet joints, and numerous construction methods and theories. Students in irrigation engineering completed courses in water flow, canal surveying, local geography, as well as legal and economic principles of water rights. While students spent well over half their semester hours in the classroom, the faculty intentionally increased the number of practical experience hours for every course by three to five hours each semester.⁷³

Professors Owens and Hampsen particularly focused on improving the practical skills of students in the electrical and mechanical areas. Freshmen and sophomores spent a majority of their time in the general physics and chemistry laboratories, with a few additional hours spent in the small University workshop learning how to maintain tools and field equipment. Juniors and seniors completed more hours in the electrical laboratory and studying the campus electrical systems. They studied the theory of electricity and magnetism, as well as specialized work in dynamos, electrical wiring systems for railways and cities, telephone and telegraph systems and special applications of electricity to mining, construction, and

⁷² "Engineering." *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 93-105. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

⁷³ "Engineering." *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 93-105. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

ventilation. Steam engineering students worked with the University boiler system and hired themselves out during the summer months to local railway companies.⁷⁴

Faculty members began working more closely with the School of Mechanic Arts, the preparatory school for high school students, in 1896. Charles Richards, the instructor of practical mechanics and manual training for the college since 1892, became the director of the new two year course which essentially provided better academic and technical training for students interested in attending the Industrial College. Richards stated in his first official announcement that “the almost total absence of secondary technical instruction in this state” was the missing link between the school system and industry that hampered Nebraska’s potential for further economic development. He believed that supply would generate demand; by training “a large number of students in mechanic arts and engineering pursuits there must shortly result in the establishment of manufacturing interests.” Richards supported a philosophy that industry and manufacturing would spring up following education, a very progressive idea, but completely opposite of what had happened in every other Midwestern state. In Michigan, Wisconsin, and Iowa, businessmen supported engineering education following the growth of manufacturing and allied industries.⁷⁵

However, Richards did correctly identify the pattern of strong technical education programs benefiting from large manufacturing interests and asserted firmly that the success of this modern engineering education relied on a strong foundation of practical training and experience. He applied this philosophy of applied value to every subject the new program offered, including mathematics, English, political economy, and science courses. Students

⁷⁴ “Engineering.” *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 93-105. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

⁷⁵ Charles R. Richards, “The School of Mechanic Arts.” *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 191-197. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

studied mathematical applications in mechanical and engineering work, descriptive writing practices, economic and business applications, and laboratory methods in the sciences.

Richards actually hoped to entice many of these short-course students into the collegiate programs. In fact, the short course students had more practical hours in the wood and metal shops than the collegiate students did. But the program allowed the faculty to incorporate more technical training and hands-on experience than at any previous time in the University's twenty year history.⁷⁶

With this explicit commitment to practical training, Richards and Hampton dramatically improved the equipment and tools available to students. They constructed a large workshop that contained twenty-five work benches with carpenter's tools, sixteen lathes, a scroll saw, and specialized hand tools. In the forge shop they purchased twenty-four stationary forges, complete with anvil and tools, a twenty-six inch power-feed drill press, and numerous grinders and hand tools. They powered the workshops with a 25 horsepower Weston steam engine and a ten horsepower steam engine, both tied into the campus boiler system. In a matter of just two years, Richards and Hampton went from nearly nothing in terms of tools and shop equipment, to one of the largest and well-equipped wood shop and forge in the Midwest. Most mechanic arts instructors from Michigan west to Kansas felt lucky to have half the workstations and tools that Nebraska had.⁷⁷

Charles Bessey resumed his post as the Dean of the Industrial College in 1896 following the departure of Charles Ingersoll. He hired William Brown, a certified electrical engineering and 1892 graduate of Johns Hopkins, to assist with the electrical and steam

⁷⁶ Charles R. Richards, "The School of Mechanic Arts." *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 191-197. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

⁷⁷ Charles R. Richards, "The School of Mechanic Arts." *The University of Nebraska Calendar, 1895-1896* (Lincoln: Published by the University, 1896), 140-141. RG 00/07, Bulletins and Catalogues, Box 3, Folder 4. University Archives / Special Collections – University of Nebraska-Lincoln.

engineering coursework. He also increased the entry requirements for incoming freshmen. He increased the mathematics requirement from simple algebra and geometry to algebra with logarithms, plane and solid geometry, and trigonometry for engineering majors. He also mandated at least one year of German or French, and a year of botany, chemistry, or physics with a semester of laboratory experience. While he maintained the basic curriculum for undergraduates, Bessey also continued to expand the engineering options. He created a new municipal engineering program within the civil engineering department and fully separated the electrical and steam engineering curricula to make them distinct majors. Bessey also helped Owens, Richards, and Brown get the funding to expand the engineering laboratory to include a 25 kilo-watt motor with fifteen dynamos for electrical production and experimentation. Richards and Hampton purchased a new 100 horsepower condensing steam engine, which also assisted with electrical production for portions of the campus.⁷⁸

Building on this positive momentum, Richards and Bessey combined forces to expand the engineering department and begin construction of a new building beginning in 1897. They considered it urgent to address the continued shortage of shop equipment, which threatened to undermine both morale and enrollment. Richards informed the Chancellor and Board of Regents in 1897 that half the second-year mechanical engineering students dropped out, because the equipment for the department of practical mechanics had not yet arrived, meaning that the students were unable to take the required five hours of shop work. Although the school offered to let these engineering students substitute “other work in the University as

⁷⁸ “Engineering.” *The University of Nebraska Calendar, 1896-1897* (Lincoln: Published by the University, 1897), 102-117. RG 00/07, Bulletins and Calendars, Box 3, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln. For a more detailed analysis of Bessey’s administrative and academic work in the 1890s see Richard A. Overfield, *Science with Practice, Charles E. Bessey and the Maturing of American Botany* (Ames: Iowa State University Press, 1993), 100-130. Overfield focuses primarily on Bessey’s work in botany and agricultural sciences, but Bessey also spent a significant amount of time promoting professional societies and the connections of the University during the 1890s and 1900s.

the students were prepared to take,” the would-be engineers considered this a poor choice. Richards warned the Board that unless funding for equipment arrived immediately, the University was in danger of losing “a large percentage of students now in attendance,” not to mention the other half that had already dropped out rather than take humanities courses, or at best botany and zoology.⁷⁹

Continuing his aggressive push for curriculum expansion, Richards asked MacLean to re-organize the Department of Mechanics into a Department of Mechanical Engineering in the spring of 1898. Richards, Hampson, and Chatburn had finally acquired enough wood and machine tool equipment to get started, and Richards assumed that the remaining equipment requests from the 1897 school year, amounting to \$1,500, would soon arrive. Richards warned that unless the University instituted the new mechanical engineering program without delay, the students enrolled in the School of Mechanic Arts would probably leave for a different institution, depriving the state of “well-trained engineers.” Richards also emphasized the importance of keeping the practical mechanics and mechanical engineering curriculum combined. He feared that separating the two programs would drastically reduce the skill and expertise of engineering students, since “practical mechanics was such an essential factor in mechanical engineering.”⁸⁰

Richards and the other engineering faculty hoped that by combining the administration of the engineering programs, they could more easily persuade the Board to fund the engineering department’s requests and still leave the faculty alone to conduct their curriculum

⁷⁹ C.R. Richards, “Report from the School of Mechanic Arts for the Year 1897-1898.” Typewritten letter dated 4/12/98. RG 01/01/01, General Files, Box 13, Folder 102. University Archives / Special Collections – University of Nebraska-Lincoln. Richards listed the students enrolled in the School of Mechanics arts, with 29 first year students and 8 second year students. This meant the University had already lost four students and stood to lose at least another 15 if no equipment for the mechanics department arrived within the year.

⁸⁰ C.R. Richards typed letter to Chancellor MacLean, dated 31 March, 1898. RG 01/01/01, General Files, Box 13, Folder 102. University Archives / Special Collections – University of Nebraska-Lincoln.

as they saw fit. Bessey promptly followed up Richard's letter with a detailed report of the increasing number of students and the funding requirements to adequately address the department's space, equipment, and faculty needs. The very next day, Bessey sent another letter asking that the School of Agriculture be reorganized to "afford a sound technical training together with a liberal education," for farmers and their wives. The faculty of the Industrial College had firmly established their view that professional engineers and scientists had to have both theoretical knowledge and practical training.⁸¹

Bessey and the engineering faculty successfully completed the organization of the engineering college in 1899. Workers finished construction of the Mechanic Arts Hall, funded two years earlier by the state legislature. The faculty moved all their lecture halls, the technical and mathematics libraries, foundry, and machine shop into the new building before the start of classes in 1899. Stout moved all of the surveying equipment to the new building, and Robert Owen moved several of the electrical engineering laboratories into the basement. Faculty reported over the next two years that their workshop and laboratory space had more than doubled, and the new equipment that had stayed in crates during the previous two semesters now received extensive use by students and staff.⁸²

Faculty and students in the engineering programs benefited from a growing urban and transportation economy during the 1890s in Nebraska. Though the state's population only

⁸¹ The original letter was reprinted in the 1899 *Regent's Report*. See Charles Bessey, "Report of the Dean of the Industrial College." *Fourteenth Biennial Report of the Board of Regents of the University of Nebraska, 1899* (Lincoln: University Press, 1899), 19. RG 01/05, Box 2, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln.; and Charles Bessey, "Report of the Committee on Reorganization of the School of Agriculture," typed letter dated 13 April 1898. RG 01/01/01, General Files, Box 13, Folder 101. University Archives / Special Collections – University of Nebraska-Lincoln.

⁸² C.R. Richards, "Report of the Director of the School of Mechanic Arts." *Fourteenth Biennial Report of the Board of Regents of the University of Nebraska, 1899* (Lincoln: University Press, 1899), 24. RG 01/05, Box 2, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln. Oscar Stout, Morgan Brooks, and Charles Richards gave full reports of their curriculum, workshop equipment, and laboratory use in their course descriptions for the 1900 Catalogue. See "Engineering." *The University of Nebraska Catalogue for the year 1899-1900* (Lincoln: The University of Nebraska Press, 1900), 188-242. RG 00/07, Bulletins and Catalogues, Box 2, Folder 5. University Archives / Special Collections – University of Nebraska-Lincoln.

increased by 12.7 percent between 1890 and 1910, the majority of new settlers tended to settle in cities. This development prompted the faculty and administration of the Industrial College to increase the water, sewerage, and electrical engineering programs, eventually organizing the municipal engineering department in 1896. The expansion of electrical lighting and power distribution also boosted student numbers in the electrical engineering program.

Nebraska workers began to diversify between 1890 and 1900 as well. Farming and agricultural processing remained the largest business in the state. Starting in the 1890s, farmers began relying on more machinery, such as planters, cultivators, and threshers, to help them cultivate and harvest their crops. This meant that mechanical engineers and mechanics became much more important to the local town economies. Equally significant, manufacturing investment tripled from \$37.5 million to almost \$1 billion between 1890 and 1910. Seventy-five percent of the manufacturing laborers worked in food processing or farm implement manufacturing plants. Overall, Nebraska still lacked heavy industry, a factor that the University's Board of Regents cited in their initial reluctance to expand engineering programs. But it was the growth of the railroads that made the biggest difference for the University, since the railroads ended up hiring a significant share of the skilled workers and engineers who graduated. By the 1890s in Nebraska, railroads provided most of the transportation between towns and shipped in nearly all of the manufactured goods people used. The frontier setting forced the University to provide more civil engineers who could assist with the surveying of land and railroad lines.⁸³

⁸³ James C. Olson and Ronald C. Naugle, *History of Nebraska* (Lincoln: University of Nebraska Press, 1997), 244-254. Though some mechanization of farming occurred in the 1890s and early 1900s, significantly more occurred after 1917, after nearly 56,000 men left to serve in the military. For more detailed figures on farm production, prices, and the wartime and post-war labor force, see Olson and Naugle, *History of Nebraska* (Lincoln: University of Nebraska Press, 1997), 285-291. On the farming frontier from the plains to the west coast between 1865 and 1900 see Gilbert C. Fite, *The Farmers' Frontier, 1865-1900* (New York: Hold, Rinehart and Winston, 1966). For an analysis of farm mechanization and the expansion of prairie agriculture see Fred A.

Although the University of Nebraska got a slower start in many ways than its nearby Midwest counterparts, other historians have also concluded that by 1900, the institution was poised at the start of a golden age for faculty and students. Journalists of the time saw a hunger for educational access, noting that a greater percentage of the western population attended college than in eastern states. Chamberlain, Bessey, and MacLain had prepared to meet this demand by creating the initiative for tangible institutional expansion. These leaders had improved salaries, appropriated significant funding requests for new buildings, and organized the colleges of the University to provide a complete spectrum of technical, scientific, and classical studies. Faculty took advantage of new research laboratories and massive increases in library funding to acquire journals and books relevant to their research. By 1908, over 600 students enrolled in the engineering departments. Charles Richards, the first dean of the engineering college, had a staff of fifteen professors and usually twice that number of instructors and support staff. He even helped design a new engineering building in 1900, to accommodate the growing student enrollment and help faculty join their counterparts in Iowa, Wisconsin, and Michigan in adding a focus on original research. Engineering faculty became heavily involved in the “good roads” campaign of the 1920s, and George Chatburn helped design and plan the construction of many of the state’s new roads between Omaha in the East and Kearney and North Platte in the West. Oscar Stout, who became the dean of the College of Engineering following Richards’ retirement in 1912, provided detailed studies of Nebraska’s water supplies through the 1920s.⁸⁴

Shannon, *The Farmer’s Last Frontier: Agriculture, 1860-1897* (New York: Farrar & Rinehart, Inc, 1945), 125-172. For a discussion of Midwestern farming, industrial and white collar workers between 1880 and 1930 see Daniel Nelson, *Farm and Factory, Workers in the Midwest 1880-1990* (Bloomington: Indiana University Press, 1995), 1-112.

⁸⁴ Robert N. Manley, *Centennial History of the University of Nebraska, Frontier University (1869-1919)* (Lincoln: University of Nebraska Press, 1969), 125, 147-159. The statistical variations between eastern and western states was compiled by the United States Bureau of Education in 1900 and included in a *Collier’s* article

Engineers in Nebraska did not have the industrial base or manufacturing proximity to become as well-known as many of their eastern colleagues. They did, however, fan out into the state and support the transition from a pioneer culture to a modern and industrialized society with an expanding economy and transportation infrastructure. Once administrators and faculty members finally realized the importance of technical training as a part of scientific learning and chose to invest in expanded engineering education, the state's land-grant institution truly began serving the citizens of the state.

Conclusion

In 1870, eight years after the passage of the Morrill Land-Grant Act⁸⁵, just over 1,200 total students attended land-grant designated colleges. By the 1880s, this number had grown to over 5,000. And at the turn of the century, land-grant institutions accounted for nearly 40,000 students who attended college, over 18,000 of whom graduated with degrees in agriculture or engineering. Even the University of Nebraska, located in a sparsely populated frontier state and getting started a decade later than many of the original land-grant institutions, quickly surpassed its regional peers and topped 2,000 students by 1900. Engineering departments, at Midwestern schools, such as the Michigan Agricultural College and the Iowa Agricultural and Mechanic Arts College, routinely drew some of the largest

by Richard Lloyd Jones on September 14, 1908. Some of the details regarding the College of Engineering were part of a vignette in Robert E. Knoll, *Prairie University, A History of the University of Nebraska* (Lincoln: University of Nebraska Press, 1995), 49-50.

⁸⁵ This act was officially titled "An Act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts," a rather unwieldy title. Legislators quickly dubbed it Morrill's Land-Grant Act for Education. See, for example, *The Congressional Globe*, 1st Session, 35th Congress, Vol. 28, pt. 2 (City of Washington: Printed at the Office of John C. Rivers, 1858): 1692-1697, 1793, and 1989.

attendance numbers in the nation, behind only Cornell University and the Massachusetts Institute of Technology by late 1880s and early 1890s.⁸⁶

While the 1862 Morrill Land-Grant Act specified that students should have access to agriculture and mechanic arts, political and public sentiment in the years immediately thereafter consistently referred to the institutions as agricultural colleges, primarily because most institutions that accepted the funds were already designated as agricultural colleges by their original charters. A sizable portion of the student body continued to focus on agricultural coursework through the end of the nineteenth century, especially at colleges initially founded as agricultural schools in the East and Midwest. However, a growing number of students took up engineering beginning in the mid-1870s, particularly at Midwest institutions. By the 1890s, students from land-grant schools with engineering degrees, encompassing civil, mechanical, electrical, and mining studies, easily outnumbered students with agricultural degrees. Michigan's land-grant college graduated 245 engineering students in 1899, Iowa's 340, Nebraska's 236, and Wisconsin's 294. In the East, Cornell University in New York set the national standard with 774 graduates, made up primarily of mechanical engineers. However, other Eastern schools fell well short of graduation rates seen in the Midwest. Rutgers University in New Jersey graduated only 48 engineering students and Sheffield Scientific School of Yale College in Connecticut had only 44 engineering graduates in 1899.⁸⁷

⁸⁶ Statistics were compiled from tables in the *Report of the Commissioner of Education* between the years 1870 and 1901. See *Report of the Commissioner of Education Made to the Secretary of the Interior* (Washington: Government Printing Office).

⁸⁷ Statistics compiled from tables in the *Report of the Commissioner of Education* between 1870 and 1901. The *Report* provided the first detailed breakdown of specific majors in 1899-1900. As early as 1873 statistics for Schools of Science were provided, and by 1887 specific numbers were provided for civil and mechanical engineering degrees at a handful of colleges, but no specific agricultural degree was listed for any school until 1899. See *Report of the Commissioner of Education Made to the Secretary of the Interior* (Washington: Government Printing Office).

Given the impressive numbers of Midwest land-grant graduates, it is crucial to note that while a number of historians have investigated various aspects of the history of engineering education, the role of America's early land-grant universities has attracted very limited attention over the last thirty years. Previous scholars have primarily emphasized broad institutional growth and the local importance of college graduates to economic growth and manufacturing. This research adds to the existing scholarship by investigating the interplay of engineering curricula, practical training, and professional engineering standards. The preceding analysis of these factors leads to the conclusion that Midwestern institutions and their graduates played a central role in the changing nature of professional engineering as the country entered the twentieth century. While many famous Eastern schools lagged behind, the rapid growth of Midwestern land-grant institutions reshaped the demographics of America's pool of formally-trained engineers. This study of the early years of engineering education at Midwestern land-grant colleges also provides important insights into the nature of Midwestern culture and the changing nature of professionalism for middle-class Americans in frontier states.

Many historians might place the end of the 1862 Morrill Act philosophy in 1914, with the passage of the Smith-Lever Act and furthered by the 1917 Smith-Hughes Act. These legislative acts provided funding for technical and vocational education at public high schools, and officially transferred the funding provisions for such education at colleges, universities, and other technical institutes to the lower grades. However, Midwest land-grant school administrators and faculty had already begun the transition to a new educational philosophy by the last decade of the nineteenth century. Thanks to the persistent lobbying by leaders who pressed the need for expanded programs and facilities, faculty and engineering

students had better access to laboratories and modern equipment. Land-grant university professors also found new sources of funding with the help of the 1887 Hatch Act and an increase in financial gifts from wealthy businessmen. Administrators promoted connections to professional societies of all stripes, clearly showing their awareness of the importance of disciplinary associations and staking a claim to a higher intellectual status for Midwest faculty. And professionals, particularly those involved with the Society for Promoting Engineering Education after 1893, became much more involved in determining the curriculum standards and technical skills that students were expected to master.⁸⁸

Engineers changed from skilled mechanics to educated professionals during the last half of the nineteenth century. During this period, the culture of technical knowledge which they existed and worked in, adapted to, and even transformed through their educational and professional experiences, played a crucial role in the public perception of expertise and the practical applications of scientific knowledge. By the start of the twentieth century, engineers and engineering education had already begun to enter a new period of modernization and professionalization, distinctly different from the nineteenth century. Corporate capitalists, the decline of progressive politics and culture, and the expansion of public high schools separated

⁸⁸ For the wording of the Smith-Lever Act see *The Land Grant Tradition* (Washington D.C.: National Association of State Universities and Land-Grant Colleges, 1995), 21-23. For an analysis of how the Smith-Lever Act and Smith-Hughes Act contributed to national educational changes see Lawrence A. Cremin, *American Education, The Metropolitan Experience 1876-1980* (New York: Harper & Row Publishers, 1988), 476-480, 549; Lawrence Cremin, *The Transformation of the School, Progressivism in American Education 1876-1957* (New York: Vintage Books and Random House, 1961), 56-57, 84, ; and David F. Noble, *America By Design, Science, Technology and the Rise of Corporate Capitalism* (New York: Oxford University Press, 1977), 214, 310. For a more recent analysis of why experiment station largely failed at land-grant colleges see David Harmon, "Collegiate Conflict: Internal Dissension at Land-Grant Colleges and the Failure to Establish Engineering Experiment Stations." In *Engineering in a Land-Grant Context, The Past, Present, and Future of an Idea*, ed. Alan I Marcus (West Lafayette: Purdue University Press, 2005), 7-26. College Professors also worked to promote the economic benefits of their programs during the 1890s. F.R. Hutton, a mechanical engineering professor from Columbia University wrote an article that got picked up by the Michigan Agricultural College newspapers, and likely others, discussing how technical education and land-grant colleges contributed in very specific ways to the massive industrialization of the nation in the late nineteenth-century. See F.R. Hutton, "The Economic Significance of Technical Education." *The M.A.C. Record*, 21 June 1898: 5-6.

the educational spheres of mechanical arts based on trade skills from professional engineering based in scientific research. Historians have acknowledged the rise of modern engineering and science based education starting in the early twentieth century, but too often assumed that ideas and actions of progress came from the already-industrialized East. In truth, a substantial basis for what historians see as modern engineering lies in the educational philosophies and practices of nineteenth-century Midwestern land-grant college administrators and professors who developed a culture of technical knowledge that informed and influenced national perceptions and professional standards.

BIBLIOGRAPHY

University Archives Publications, Manuscripts, and Reports

Iowa State University

(Iowa State University Library/Special Collections)

Annual and Biennial Reports of the Secretary of the Iowa State Agricultural College, 1858-1914.

Benjamin F. Gue Papers, 1848-1903.

Iowa Agricultural College Bachelor Theses, 1878-1923.

Iowa Agricultural College Catalogue, 1880-1914.

Presidents' Papers

Adonijah Welch Papers, 1869-1889.

Seaman Knapp Papers, 1879-1884.

Leigh S.J. Hunt Papers, 1885-1886.

William Chamberlain Papers, 1886-1890.

William Beardshear Papers, 1891-1902.

Albert B. Storms Papers, 1903-1910.

Michigan State University

(Michigan State University Archives and Historical Collections)

Annual and Biennial Reports of the Secretary of the State Board of Agriculture, 1866-1910.

Catalogue of the Officers and Students of the State Agricultural College of Michigan, 1857-1900.

Madison Kuhn Collection Papers, 1827-1966.

Presidents' Papers

Joseph Williams Papers, 1855-1859.

Lewis R. Fiske Papers, 1859-1862.

Theophilus C. Abbot Papers, 1862-1884.

Edwin Willits Papers, 1885-1889.

Oscar Clute Papers, 1889-1893.

Lewis Gorton Papers, 1893-1895.

Jonathan L. Snyder Papers, 1895-1915.

Frank S. Kedzie Papers, 1915-1920.

University of Nebraska

(University Archives-Special Collections – University of Nebraska-Lincoln.)

Biennial Report of the Board of Regents for the University of Nebraska, 1871-1920.

Bulletins and Catalogues of the University of Nebraska, 1873-1905.

General Files of the Board of Regents, 1870-1901.

General History of the University, 1869-1926.

Presidents' Papers

Allen R. Benton Papers, 1871-1876.

Edmund B. Fairchild Paper, 1876-1882.

Henry E. Hitchcock Papers, 1882-1883.

Irving J. Manatt Papers, 1884-1888.

Charles E. Bessey Papers, 1888-1891.

James H. Canfield Papers, 1891-1895.

George E. MacLean Papers, 1885-1899.

E. Benjamin Andrews Papers, 1900-1908.

University Commencements, 1869-1902.

University of Wisconsin
(The University of Wisconsin Archives)

Board of Regents Papers, 1850-1971.

Presidents' Papers

John Lathrop Papers, 1848-1858.

Henry Barnard Papers, 1859-1861.

Paul Chadbourne Papers, 1867-1870.

John Twombly Papers, 1871-1874.

John Bascom Papers, 1874-1887.

Thomas Chamberlain Papers, 1887-1892.

Charles Kendall Adams Papers, 1892-1902.

Charles R. Van Hise Papers, 1903-1918.

Proceedings of the Board of Regents, 1866-1907.

Annual and Biennial Reports of the Board of Regents for the University of Wisconsin,
1849-1920.

The University of Wisconsin Catalogue, 1859-1903.

University Newspapers and Student Publications

The Aegis / The Badger, The University of Wisconsin-Madison

The Alumnus, Iowa State University

The Ames Intelligencer, Iowa

The Aurora, Iowa State University

The College Speculum, Michigan State University

The Daily Cardinal, The University of Wisconsin-Madison

The Hesperian, The University of Nebraska-Lincoln

The I.A.C. Student, Iowa State University

MAC Record, Michigan State University

The Progressive Farmer, Iowa and Iowa State University

The Story County Aegis, Iowa

The University Press, The University of Wisconsin-Madison

Articles, Manuscripts, and Books

Adams, Eugene T. *The American Idea*. New York: Harper & Brothers Publishers, 1942.

Akin, William E. *Technocracy and the American Dream: The Technocrat Movement, 1900-1941*. Berkeley: University of California Press, 1977.

The Alumni Association. *Stevens 75th Anniversary, Commemorating Seventy-Five Years of Accomplishment in Engineering Education*. Hoboken: the Alumni Association of the Stevens Institute of Technology, 1945.

Anderson, Terry L. and Peter J. Hill, editors. *The Political Economy of the American West*. Lanham, MD: Rowman & Littlefield Publishers, Inc., 1994.

Angevine, Robert G. *The Railroad and the State: War, Politics, and Technology in Nineteenth-Century America*. Stanford: Stanford University Press, 2004.

Ansell, George S. et. al. *Engineering in Society: Engineering Education and Practice in the United States*. Washington, D.C.: National Academy Press, 1985.

Armstrong, W.H.G. *A Social History of Engineering*. Boulder, CO: Westview Press, 1961.

Artz, Frederick. *The Development of Technical Education in France, 1500-1850*. Cambridge: The MIT Press, 1966.

Aurner, Clarence Ray. *History of Education in Iowa*. Vol. 1-5. Iowa City: The State Historical Society of Iowa, 1916.

Bailey, Joseph Cannon. *Seaman A. Knapp: Schoolmaster of American Agriculture*. New York: Columbia University Press, 1948.

Baker, Ira O. "Engineering Education in the United States at the End of the Century." *Science*, New Series, Vol. 12, No. 305 (November 2, 1900), 666-674.

- Bald, F. Clever. *Michigan in Four Centuries*. New York: Harper & Row Publishers, 1961.
- Barnard, Henry. *Report of the Commissioner of Education, 1886-1910*. Washington, D.C.: Government Printing Office.
- Barnes, Sherman B. "The Entry of Science and History in the College Curriculum, 1865 1914." *History of Education Quarterly*, Vol. 4, No. 1 (March, 1964), 44-58.
- Barney, William L. editor. *A Companion to 19th-Century America*. Malden, MA: Blackwell Publishing Ltd, 2001.
- Belanger, Dian Olson. *Enabling American Innovation: Engineering and the National Science Foundation*. West Lafayette: Purdue University Press, 1998.
- Benedict, Ruth. *Patterns of Culture*. Boston: Houghton Mifflin, 1959.
- Bennett, Charles A. *History of Manual and Industrial Education 1870-1917*. Peoria, IL: The Manual Arts Press, 1937.
- Bensel, Richard Franklin. *Yankee Leviathan: The Origins of Central State Authority in America, 1859-1877*. New York: Cambridge University Press, 1990.
- Bensel, Richard Franklin. *The Political Economy of American Industrialization*. New York: Cambridge University Press, 2000.
- Bernal, J.D. *Science and Industry in the Nineteenth Century*. Bloomington: Indiana University Press, 1953.
- Bessey, Charles E. "Science and Culture." *Science*, New Series, Vol. 4, No. 83 (July 31,] 1896), 121-124.
- Betts, Clifford A. et. al. *The Civil Engineer: His Origins*. New York: American Society of Civil Engineers, 1970.
- Bezilla, Michael. *Engineering Education at Penn State: A Century in the Land-Grant Tradition*. University Park: The Pennsylvania State University Press, 1981.
- Bigelow, Jacob. "An Address on the Limits of Education." *Read before the Massachusetts Institute of Technology, November 16, 1865*. Boston: E.P. Dutton & Company, 1865.
- Black, Henry and Stanley Ring. *IES One Hundred: A History of the Iowa Engineering Society 1889-1989*. Des Moines: The Iowa Engineering Society, 1989.
- Bledstein, Burton J. *The Culture of Professionalism: The middle class and the development of higher education in America*. New York: W.W. Norton & Co., 1976.

- Bliss, Ralph K. *History of Cooperative Agriculture and Home Economics Extension in Iowa The First Fifty Years*. Ames: Iowa State University of Science and Technology, 1960.
- Bogue, Allan G. and Robert Taylor. *The University of Wisconsin, One Hundred and Twenty Five Years*. Madison: The University of Wisconsin Press, 1975.
- Bolton, John H., editor. *A History of the Iowa Engineering Society: 75 Years of Growth*. Des Moines: The Iowa Engineering Society, 1967.
- Bowen, Francis. *American Political Economy; Including Strictures on the Management of the Currency and the Finances since 1861*. New York: Scribner, Armstrong, And Co., 1874.
- Bowen, Francis. *The Principles of Political Economy Applied to The Condition, the Resources, and the Institutions of the American People*. Boston: Little, Brown, and Company, 1859.
- Bradfield, Richard. "The Sciences, Pure and Applied, in the First Century of the Land-Grant Institutions." *Science Education*, Vol. 46, No. 3 (April, 1962), 240-247.
- Brigham, Johnson. *Iowa: Its History and Its Foremost Citizens*. Vol. 1-2. Chicago: S.J. Clarke Publishing Company, 1918.
- Brown, John K. *The Baldwin Locomotive Works 1831-1915*. Baltimore: The Johns Hopkins University Press, 1995.
- Bruce, Robert V. *The Launching of Modern American Science, 1846-1876*. New York: Alfred A. Knopf, 1987.
- Buenker, John. "Sifting and Winnowing: The Historical Context." in *Academic Freedom on Trial, 100 Years of Sifting and Winnowing at the University of Wisconsin-Madison*. Madison: Office of University Publications, 1998.
- Buenker, John. *The History of Wisconsin, Volume IV, The Progressive Era, 1893-1914*. Madison: State Historical Society of Wisconsin, 1998.
- Burnham, John C. *Science in America: Historical Selections*. New York: Holt, Rinehart and Winston, Inc., 1971.
- Bush, Lawrence and William B. Lacy. *Science, Agriculture, and the Politics of Research*. Boulder, CO: Westview Press, 1983.
- Butler, Nicholas Murray, editor. *Monographs on Education in the United States*, Volume I-II. Albany: J.B. Lyon Company, 1900.

- Butts, R. Freeman. *Public Education in the United States, From Revolution to Reform*. New York: Holt, Rinehart and Winston, 1978.
- Butts, R. Freeman and Lawrence Cremin. *A History of Education in American Culture*. New York: Holt, Rinehart and Winston, 1953.
- Cairnes, J.E. *Essays in Political Economy: Theoretical and Applied*. London: MacMillan and Co., 1873.
- Calhoun, Daniel, editor. *The Educating of Americans, A Documentary History*. Boston: Houghton Mifflin Company, 1969.
- Calhoun, Daniel H. *The American Civil Engineer, Origins and Conflict*. Cambridge: Harvard University Press, 1960.
- Callahan, Raymond E. *Education and the Cult of Efficiency: A Study of the Social Forces that have shaped the administration of public schools*. Chicago: The University of Chicago Press, 1962.
- Calvert, Monte A. *The Mechanical Engineer in America, 1830-1910*. Baltimore: Johns Hopkins University Press, 1967.
- Carpenter, R.C. "Engineering Laboratories." *Science*, Vol. 22, No. 561 (November 3, 1893), 241-242.
- Carr, Ezra S. *The Patrons of Husbandry on the Pacific Coast*. San Francisco: A.L. Bancroft and Company, 1875.
- Carr, Hobart C. *Early History of Iowa Railroads*. New York: Arno Press, 1981.
- Chittenden, Russell. *History of the Sheffield Scientific School of Yale University, 1846-1922*, Vol. 1-2. New Haven: Yale University Press, 1928.
- Chudacoff, Howard P. *Mobile Americans, Residential and Social Mobility in Omaha, 1880-1920*. New York: Oxford University Press, 1972.
- Clark, Geoffrey W. *History of Stevens Institute of Technology: A Record of Broad-Based Curricula and Technogenesis*. Jersey City, NJ: Jensen/Daniels, Publishers, 2000.
- Coben, Stanley. *Rebellion against Victorianism: the impetus for cultural change in the 1920s America*. New York: Oxford University Press, 1991.
- Coben, Stanley and Lorman Ratner, editors. *The Development of an American culture*. Englewood Cliffs, NJ: Prentice-Hall, 1970.
- Cochran, Thomas. *Frontiers of Change: Early Industrialization in America*. New York:

- Oxford University Press, 1981.
- Cogswell, Seddie Jr. *Tenure, Nativity and Age as Factors in Iowa Agriculture, 1850-1880*. Ames: The Iowa State University Press, 1975.
- Cohen, Sol, editor. *Education in the United States: A Documentary History*, Volume 3. New York: Random House, 1974.
- Cole, Cyrenus. *A History of the People of Iowa*. Cedar Rapids: The Torch Press, 1921.
- Colman, Gould. "Pioneering in Agricultural Education: Cornell University, 1867-1890." *Agricultural History*, Vol. 36, No. 4 (1962), 200-206.
- Colman, Gould P. *Education & Agriculture: A History of the New York State College of Agriculture at Cornell University*. Ithaca: Cornell University, 1963.
- Congressional Research Service. *Expertise and Democratic Decision making: A Reader*. Washington, D.C.: U.S. Government Printing Office, 1987.
- Cravens, Hamilton, and Alan I Marcus and David M. Katzman. *Technical Knowledge in American Culture: Science, Technology, and Medicine Since the Early 1800s*. Tuscaloosa: University of Alabama Press, 1996.
- Cotton, Barbara, editor. *The 1890 Land-Grant Colleges: A Centennial Review*. Washington, D.C.: The Agricultural History Society, 1992.
- Creigh, Dorothy Weyer. *Nebraska, A Bicentennial History*. New York: W.W. Norton & Company, Inc, 1977.
- Cremin, Lawrence A. *American Education: The Metropolitan Experience, 1876-1980*. New York: Harper & Row Publishers, 1988.
- Cremin, Lawrence A. *American Education: The National Experience, 1783-1876*. New York: Harper & Row, Publishers, 1980.
- Cremin, Lawrence A. *The Transformation of the School: Progressivism in American Education, 1876-1957*. New York: Vintage Books, 1961.
- Cross, Coy F. II. *Go West Young Man: Horace Greeley's Vision for America*. Albuquerque: University of New Mexico Press, 1995.
- Cross, Coy F. II. *Justin Smith Morrill, Father of the Land-Grant Colleges*. East Lansing: Michigan State University Press, 1999.
- Current, Richard N. *The History of Wisconsin, Volume II, The Civil War Era, 1848-1873*. Madison: State Historical Society of Wisconsin, 1976.

- Current, Richard Nelson. *Wisconsin, A Bicentennial History*. New York: W.W. Norton & Company, Inc., 1977.
- Curti, Merle. *The Social Ideas of American Educators*. New York: Charles Scribner's Sons, 1935.
- Curti, Merle and Vernon Carstensen. *The University of Wisconsin, A History, 1848-1925*, Volume I-II. Madison: University of Wisconsin Press, 1949.
- Dabney, Charles W. "The National University." *Science*, New Series, Vol. 5, No. 114 (March 5, 1897), 378-384.
- Dailey, Christie. "Implementation of the land-grant philosophy during the early years at IAC 1858-1890." (Masters Thesis, Iowa State University, 1982).
- Dain, Floyd R. *Education in the Wilderness*. Lansing: Michigan Historical Commission, 1968.
- Danbom, David B. *Born in the Country: A History of Rural America*. Baltimore: Johns Hopkins University Press, 1995.
- Danbom, David B. "The Agricultural Experiment Station and Professionalization: Scientists' Goals for Agriculture." *Agricultural History*, Vol. 60 (Spring 1986), 246-255.
- Daniels, George H. *American Science in the Age of Jackson*. Tuscaloosa: The University of Alabama Press, 1968.
- Daniels, George H. *Science in American Society, A Social History*. New York: Alfred A. Knopf, 1971.
- Daniels, George H., editor. *Nineteenth-Century American Science, A Reappraisal*. Evanston: Northwestern University Press, 1972.
- Day, Charles R. *Education for the Industrial World: The Ecoles d'Arts et Metiers and the Rise of French Industrial Engineering*. Cambridge: The MIT Press, 1987.
- De Bow, J.D.B. *The Industrial Resources, Etc., of the Southern and Western States*, Volumes I-III. New York: The Office of the De Bow Review, 1852.
- Diggs, D. Teddy. "Education for Head or Hand: Land Grant Universities of Utah and Wyoming." *Annals of Wyoming*, Vol. 58, No. 2 (1986), 30-45.
- Dimock, Marshall E. *The New American Political Economy: A synthesis of Politics and Economics*. New York: Harper and Brothers, Publishers, 1962.

- Disbrow, Donald W. *Schools for an Urban Society*. Lansing: Michigan Historical Commission, 1968.
- Drake, William E. *The American School in Transition*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1955.
- Dubofsky, Melvyn. *Industrialism and the American Worker, 1865-1920*. Arlington Heights, IL: Harlan Davidson, Inc., 1975.
- Dudley, Richard E. "Nebraska Public School Education, 1890-1910." *Nebraska History*, Vol. 54, No. 1 (Spring 1973), 65-90.
- Dunbar, Willis F. *The Michigan Record in Higher Education*. Detroit: Wayne State University Press, 1963.
- Dunbar, Willis F. *Michigan, A History of the Wolverine State*. 3rd ed., Grand Rapids, MI: William B. Eerdmans Publishing Company, 1995.
- Durand, William F. "Dr. Robert Henry Thurston's Eighteen Years at Cornell." *Science*, New Series, Vol. 90, No. 2346 (December 15, 1939), 547-552.
- Durand, William F. *Robert Henry Thurston, a Biography*. New York: The American Society of Mechanical Engineers, 1929.
- Durbin, Paul T. *A Guide to The Culture of Science, Technology, and Medicine*. New York: The Free Press, 1980.
- Eddy, Edward Danforth Jr. *Colleges for Our Land and Time: the Land-Grant Idea in American Education*. New York: Harper & Brothers, 1957.
- Eddy, Henry T. "Address by the President before the Society for the Promotion of Engineering Education." *Science*, New Series, Vol. 6, No. 144 (October 1, 1897), 502-508.
- Edmunds, J.M. *Manufactures of the United States in 1860; Compiled from the Original Returns of the Eighth Census*. Washington: Government Printing Office, 1865.
- Eliot, Charles. *Educational Reform, Essays and Addresses*. New York: The Century Co., 1909.
- Eliot, Charles W. "The New Education." *The Atlantic Monthly* (February 1869), 204-220.
- Esterling, Kevin M. *The Political Economy of Expertise: Information and Efficiency in American Politics*. Ann Arbor: The University of Michigan Press, 2004.
- Ferrier, William Warren. *Origin and Development of the University of California*. Berkeley, CA: The Sather Gate Book Shop, 1930.

- Findlay, James. "Agency, Denominations, and the Western Colleges, 1830-1860." In *The American College in the Nineteenth Century*, edited by Roger Geiger, 167-191. Nashville: Vanderbilt University Press, 2000.
- Fisher, Berenice M. "Public Education and 'Special Interest': An Example from the History of Mechanical Engineering." *History of Education Quarterly*, Vol. 6, No. 1 (Spring, 1966), 31-40.
- Fite, Gilbert C. *The Farmers' Frontier 1865-1900*. New York: Holt, Rinehart and Winston, 1966.
- Folsom, Michael Brewster and Steven D. Lubar. *The Philosophy of Manufactures: Early Debate over Industrialization in the United States*. Cambridge: The MIT Press, 1982.
- Foner, Eric. *Free Soil, Free Labor, Free Men: The Ideology of the Republican Party Before the Civil War*. New York: Oxford University Press, 1995.
- Franklin, Fabian. *The Life of Daniel Coit Gilman*. New York: Dodd, Mead & Compnay, 1910.
- Frolik, Elvin F. and Ralston J. Graham. *The University of Nebraska-Lincoln College of Agriculture, The First Century*. Lincoln: Published by the Board of Regents of the University of Nebraska, 1987.
- Fuller, Almon H. *A History of Civil Engineering at Iowa State College*. Ames: Iowa State College Press, 1959.
- Gaskell, P. *Artisans and Machinery*. New York: Augustus M. Kelley, 1968.
- Gates, Paul W. *The Farmer's Age: Agriculture 1815-1860*. London: M.E. Sharpe, Inc., 1960.
- Gates, Paul W. *The Wisconsin Pine Lands of Cornell University, A Study in Land Policy and Absentee Ownership*. Madison: The State Historical Society of Wisconsin, 1943.
- Geiger, Roger, editor. *The American College in the Nineteenth Century*. Nashville: Vanderbilt University Press, 2000.
- Gilkey, Herbert J. *Anson Marston: Iowa State University's First Dean of Engineering*. Ames: Iowa State University College of Engineering, 1968.
- Gilman, Daniel Coit. "Our National Schools of Science." *North American Review* (October 1867), 496-507.
- Glaab, Charles N. and Lawrence H. Larson. *Factories in the Valley, Neenah-Menasha, 1870 1915*. Madison: The State Historical Society of Wisconsin, 1969.

- Glover, W. H. Farm and College, *The College of Agriculture of the University of Wisconsin, A History*. Madison: the University of Wisconsin Press, 1952.
- Goode, G. Brown. "America's Relation to the Advance of Science." *Science*, New Series, Volume 1, No. 1 (January 4, 1895), 4-9.
- Grayson, Lawrence P. *The Making of an Engineer: An Illustrated History of Engineering Education in the United States and Canada*. New York: John Wiley & Sons, 1993.
- Grayson, Lawrence P. *A Brief History of Engineering Education in the United States.* "Engineering Education, Vol. 68, No. 3 (December 1977), 246-263.
- Greeley, Horace et. al. *The Great Industries of the United States: Being an Historical Summary of the Origin, Growth, and perfection of the Chief Industrial Arts of this Country*. Hartford: J.B. Burr & Hyde, 1872.
- Gue, Benjamin F. *Origin and Early History of Iowa State College*. Long Island: Merrick Publishing Co., 1944.
- Gue, Benjamin F. *History of Iowa, From the Earliest Times to the Beginning of the Twentieth Century*. Volumes 1-4. New York: The Century History Company, 1903.
- Guralnick, Stanley M. "Sources of Misconception on the Role of Science in the Nineteenth Century American College." *Isis*, Vol. 65, No. 3 (September, 1974), 352-366.
- Halliday, S.D. *History of the Agricultural College Land Grant of July 2, 1862, together with a statement of the condition of the fund in each state of the Union*. Ithaca, NY: Press of the Journal, 1890.
- Handlin, Oscar, editor. *American Principles and Issues: The National Purpose*. New York: Holt, Rinehart and Winston, Inc., 1961.
- Harp, Gillis J. *Positivist Republic: Auguste Comte and the Reconstruction of American Liberalism, 1865-1920*. University Park: The Pennsylvania State University Press, 1995.
- Hawkins, Hugh. *Between Harvard and America: the Educational Leadership of Charles W. Eliot*. New York: Oxford University Press, 1972.
- Hays, Samuel P. *The Response to Industrialism: 1885-1914*. Chicago: The University of Chicago Press, 1957.
- Herrin, Dean. *America Transformed: Engineering and Technology in the Nineteenth Century*. Reston, VA: American Society of Civil Engineers, 2002.

- Hershock, Martin J. *The Paradox of Progress: Economic Change, Individual Enterprise, and Political Culture in Michigan 1837-1878*. Athens: Ohio University Press, 2003.
- Hildner, Ernest G. "Higher Education in Transition, 1850-1870." *Journal of the Illinois State Historical Society*, Vol. 56, No. 1 (1963), 61-73.
- Hilton, Robert T. *Iowa State University: Education for Pioneers and Pioneers in Education*. Ames: ISU Information Service, 1966.
- Hindle, Brooke and Steven Lubar. *Engines of Change: The American Industrial Revolution, 1790-1860*. Washington, D.C.: Smithsonian Institution Press, 1986.
- Hirsch, Susan E. *Roots of The American Working Class: The Industrialization of Crafts in Newark, 1800-1860*. University Park: University of Pennsylvania Press, 1978.
- History and Reminiscences of I.A.C.* Des Moines: The Geo. A. Miller Printing and Publishing Co., 1897.
- Hoffman, Mark. *"My Brave Mechanics": The First Michigan Engineers and Their Civil War*. Detroit: Wayne State University Press, 2007.
- Hofsommer, Don L. *Steel Trails of Hawkeyeland: Iowa's Railroad Experience*. Bloomington: Indiana University Press, 2005.
- Hofstadter, Richard. *The Age of Reform: From Bryan to F.D.R.* New York: Vintage Books, 1955.
- Hofstadter, Richard and Walter P. Metzger. *The Development of Academic Freedom in the United States*. New York: Columbia University Press, 1955.
- Holtz, Milton Ernest. "Peculiar and Special Features of Public Land Disposal and Early Settlement of the Eastern Nebraska Frontier, 1825-1870," (Ph.D. dissertation, University of Kansas, 1980).
- Houlette, William. *Iowa: the Pioneer Heritage*. Des Moines: Wallace-Homestead Book Company, 1970.
- Hounshell, David A. *From the American System to Mass Production 1800-1932: The Development of Manufacturing Technology in the United States*. Baltimore: The Johns Hopkins University Press, 1984.
- Howard, George E. "The State University in America." *The Atlantic Monthly*, Volume 67, Issue 401 (March, 1891), 332-342.
- Hughes, Thomas P. *Networks of Power: Electrification in Western Society, 1880-1930*.

- Baltimore: The Johns Hopkins University Press, 1983.
- Iowa and the New Education: the Story of Iowa State College 1858-1958.* Ames: Iowa State University, 1958.
- Isbell, Egbert R. *A History of Eastern Michigan University, 1849-1965.* Ypsilanti: Eastern Michigan University Press, 1971.
- Israel, Paul. *From Machine Shop to Industrial Laboratory.* Baltimore: Johns Hopkins University Press, 1992.
- Jackson, Dugald and W. Paul Jones. *The Profession of Engineering.* New York: John Wiley & Sons, 1929.
- Jackson, Dugald C. "The Potency of Engineering Schools and Their Imperfections." *Science*, New Series, Vol. 17, No. 434 (April 24, 1903), 641-652.
- James, Edmund J. *The Origin of the Land Grant Act of 1862 (The So-called Morrill Act) and Some Account of its Author Jonathan B. Turner.* The University Studies, Vol. 4, No. 1 (November, 1910), University of Illinois Bulletin, Vol. 8, No. 10 (November 1910). Urbana: University of Illinois Press, 1910.
- James, Henry. *Charles W. Eliot, President of Harvard University 1869-1909*, Volumes I-II. Boston: Houghton Mifflin Company, 1930.
- Jarausch, Konrad H., editor. *The Transformation of Higher Learning 1860-1930: Expansion, Diversification, Social Opening, and Professionalization in England, Germany, Russia, and the United States.* Chicago: The University of Chicago Press, 1983.
- Jesse, R. H. "The Function of the State University." *Science*, New Series, Vol. 14, No. 343 (Jul. 26, 1901), 138-143.
- Johnston, Arthur, editor. *Francis Bacon, The Advancement of Learning and New Atlantis.* Oxford: Clarendon Press, 1974.
- Kaiser, David, editor. *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives.* Cambridge: The MIT Press, 2005.
- Kasson, John F. *Civilizing the Machine: Technology and Republican Values in America 1776-1900.* New York: Grossman Publishers, 1976.
- Kennedy, Jos. C.G. *Manufactures in the Several States and Territories for the Year ending June 1, 1850.* New York: Norman Ross Publishing Inc., 1990.
- Kerr, W. J. *The Spirit of the Land-Grant Institutions*, an address delivered at the Forty-Fifth

Annual Convention of the Association of Land-Grant Colleges and Universities at Chicago, Ill, November 16-18, 1931.

Kevles, Daniel. "Federal Legislation for Engineering Experiment Stations: The Episode of World War I." *Technology and Culture*, Vol. 12, No. 2 (April 1971), 180-189.

Kirkman, Johanna C. Fedson. *A History of Land Grants Used for Education in Iowa*. (Master's Thesis, Iowa State University, 1928).

Kline, Ronald. "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880-1945." *Isis*, Vol. 86 (1995), 194-221.

Knoll, Robert E. *Prairie University: A History of the University of Nebraska*. Lincoln: University of Nebraska Press, 1995.

Kohlmeyer, Fred W. and Floyd L. Herum. "Science and Engineering in Agriculture: A Historical Perspective." *Technology and Culture*, Vol. 2 (Fall 1961), 368-380.

Kuhn, Madison. *Michigan State: The First Hundred Years, 1855-1955*. East Lansing: The Michigan State University Press, 1955.

The Land-Grant Tradition. Washington, D.C.: National Association of State Universities and Land-Grant Colleges, 1995.

Lang, Daniel W. "The People's College, the Mechanics' Mutual Protection and the Agricultural College Act." *History of Education Quarterly*, Vol. 18, No. 3 (Autumn, 1978), 295-321.

Larsen, Lawrence H. and Barbara J. Cottrell. *The Gate City, A History of Omaha*. Lincoln: University of Nebraska Press, 1997.

Larson, John Lauritz. *Internal Improvement: National Public Works and the Promise of Popular Government in the Early United States*. Chapel Hill: the University of North Carolina Press, 2001.

Layton, Edwin T. "Mirror Image Twins: The Communities of Science and Technology in 19th Century America." *Technology and Culture*, Vol. 12, No. 4 (October 1971), 562-580.

Layton, Edwin T. Jr. *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*. Baltimore: The Johns Hopkins University Press, 1986.

Layton, Edwin T. Jr. *Technology and Social Change in America*. New York: Harper & Row, Publishers, 1973.

Lewis, Kenneth E. *West to Far Michigan, Settling the Lower Peninsula, 1815-1860*. East

- Lansing, Michigan State University Press, 2002.
- Licht, Walter. *Industrializing America: The Nineteenth Century*. Baltimore: Johns Hopkins University Press, 1995.
- Lloyd, Henry Demarest. *Men, The Workers*. New York: Arno & The New York Times, 1969.
- Locke, Robert R. *The End of the Practical Man: Entrepreneurship and Higher Education in Germany, France, and Great Britain, 1880-1940*. London: JAI Press Inc., 1984.
- Longwell, John H. *The Centennial Report 1870-1970 of the College of Agriculture, University of Missouri – Columbia*. Columbia: University of Missouri-Columbia, 1970.
- Lyman, C.S. "Scientific Education in its Relations to Industry." *An Address delivered at the twenty-first anniversary of the Sheffield Scientific School of Yale College, July 15, 1867*. New Haven: Printed by Tuttle, Morehouse & Taylor, 1867.
- Malott, Deane W., editor. *Charting the Second Century under the Land-Grant Philosophy of Education: Addresses at the Land-Grant Centennial Convocation at Cornell University*. Ithaca: Cornell University, 1962.
- Manley, Robert N. *Centennial History of the University of Nebraska, I. Frontier University (1869-1919)*. Lincoln: University of Nebraska Press, 1969.
- Mann, Charles Riborg. *A Study of Engineering Education: Prepared for the Joint Committee on Engineering Education of the National Engineering Societies*, Bulletin 11. New York: Carnegie Foundation for the Advancement of Teaching, 1918.
- Marcus, Alan I. *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890*. Ames: Iowa State University Press, 1985.
- Marcus, Alan I. "If All the world were mechanics and farmers: democracy and the formative years of land-grant colleges in America." *Ohio Valley History*, Vol. 5, No. 1 (Spring 2005), 23-36.
- Marcus, Alan I. "The Ivory Silo: Farmer-Agricultural College Tensions in the 1870s and 1880s." *Agricultural History*, Vol. 60 (Spring 1986), 22-36.
- Marcus, Alan I. *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890*. Ames: Iowa State University Press, 1985.
- Marcus, Alan I and Howard P. Segal. *Technology in America, A Brief History*, 2nd ed. New

- York: Harcourt Brace College Publishers, 1999.
- Marcus, Alan I, editor. *Engineering in a Land-Grant Context: The Past, Present, and Future of an Idea*. West Lafayette: Purdue University Press, 2005.
- Marston, Anson. "Original Investigations by Engineering Schools a Duty to the Public and to the Profession." *Science*, New Series, Vol. 12, No. 298 (September 14, 1900), 397-400.
- Marston, Anson. *The History of Engineering: A Course of Lectures to the Senior Engineering Students of the Iowa State College*. Ames, Iowa, 1912.
- Matthaei, Julie A. *An Economic History of Women in America: Women's Work, the Sexual Division of Labor, and the Development of Capitalism*. New York: Schocken Books, 1982.
- McCain, James A. "Designed for Relevance: The Land-Grant Universities." *Centennial Review*, Vol. 14, No. 1 (1970), 91-107.
- McCaslin, Sharon. *The Development of a University Library: The University of Nebraska, 1891-1909*. (Ph.D. Dissertation, University of Nebraska-Lincoln, 1987).
- McCoy, Drew. *The Elusive Republic: Political Economy in Jeffersonian America*. Chapel Hill: University of North Carolina Press, 1980.
- McGivern, James Gregory. *First Hundred Years of Engineering Education in the United States, 1807-1907*. Spokane: Gonzaga University Press, 1960.
- McMahon, A. Michael and Stephanie A. Morris. *Technology in Industrial America: The Committee on Science and the Arts of the Franklin Institute 1824-1900*. Wilmington, DE: Scholarly Resources, Inc., 1977.
- McMath, Robert Jr. et. al. *Engineering the New South: Georgia Tech, 1885-1985*. Athens: the University of Georgia Press, 1985.
- Meiksins, Peter and Chris Smith. *Engineering Labour: Technical Workers in Comparative Perspective*. New York: Verso Publishing, 1996.
- Mendenhall, Thomas et. al. *Society for the Promotion of Engineering Education, Proceedings of the Sixth Annual Meeting, August 18-20, 1898*. Boston: Published by the Society, 1898.
- Merriman, Mansfield. "Past and Present Tendencies in Engineering Education." *Science*, New Series, Vol. 4, No. 87 (August 28, 1896), 255-261.
- Merritt, Raymond H. *Engineering in American Society, 1850-1875*. Lexington: The

- University Press of Kentucky, 1969.
- Moore, Richard Gordon. *Fields of Rich Toil: The Development of the University of Illinois College of Agriculture*. Urbana: The University of Illinois Press, 1970.
- Morgan, Barton. *A History of The Extension Service of Iowa State College*. Ames: Collegiate Press, Inc. 1934.
- Morison, Samuel Eliot, editor. *The Development of Harvard University since the Inauguration of President Eliot 1869-1929*. Cambridge: Harvard University Press, 1930.
- Mumford, Frederick B. *The Land Grant College Movement*. Bulletin 419. Columbia, Missouri (July 1940).
- Mumford, Lewis. *Technics and Civilization*. New York: Harcourt, Brace & World, Inc., 1963.
- Mutchler, Kent D. "The American Society of Civil Engineers, 1867-1880: An Organization in Search of a Constituency." (Master's Research Essay, Iowa State University, 1986).
- Nelson, Daniel. *Managers and Workers: Origins of the Twentieth-Century Factory System in the United States, 1880-1920*, 2nd ed. Madison: The University of Wisconsin Press, 1995.
- Nelson, Daniel. *Farm and Factory, Workers in the Midwest 1880-1990*. Bloomington: Indiana University Press, 1995.
- Nesbit, Robert C. *Wisconsin, A History*. Madison: The University of Wisconsin Press, 1973.
- Nesbit, Robert C. *The History of Wisconsin, Volume III: Urbanization and Industrialization, 1873-1893*. Madison: State Historical Society of Wisconsin, 1985.
- Noble, David F. *America by Design: Science, Technology, and the Rise of Corporate Capitalism*. New York: Oxford University Press, 1977.
- North, Douglass C. *The Economic Growth of the United States, 1790-1860*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1961.
- Olson, James C. and Ronald C. Naugle. *History of Nebraska*, 3rd ed. Lincoln: University of Nebraska Press, 1997.
- Orton, Edward. "The Contribution of Mechanic Arts to Educational Progress," *Rutgers College: The Celebration of the One Hundred and Fiftieth Anniversary of its Founding as Queen's College, 1766-1916*. New Brunswick: Rutgers College (1917), 273-275.

- Ostler, Jeffrey. *Prairie Populism: The Fate of Agrarian Radicalism in Kansas, Nebraska, and Iowa, 1880-1892*. Lawrence: University Press of Kansas, 1993/
- Overfield, Richard A. *Science with Practice, Charles E. Bessey and the Maturing of American Botany*. Ames: Iowa State University Press, 1993.
- Palgrave, R.H. Inglis, editor. *Dictionary of Political Economy, Volume I. A-E*. London: Macmillan and Co., 1901.
- Parker, Leonard F. "Teachers in Iowa Before 1858." *Historical Lectures upon Early Leaders in the Professions in the Territory of Iowa delivered at Iowa City 1894*. Iowa City: The State Historical Society (1894), 27-69.
- Parks, Robert J. *Democracy's Railroads: Public Enterprise in Jacksonian Michigan*. Port Washington, N.Y.: Kennikat Press, 1972.
- Payne, William Orson. *History of Story County Iowa: A Record of Settlement, Organization, Progress and Achievement*. Chicago: S.J. Clarke Publishing Co., 1911.
- Peckham, Howard H. *The Making of The University of Michigan, 1817-1967*. Ann Arbor: The University of Michigan Press, 1967.
- Perrucci, Robert and Joel E. Gerstl. *The Engineers and the Social System*. New York: John Wiley & Sons, Inc., 1969.
- Persons, Stow. *The Decline of American Gentility*. New York: Columbia University Press, 1973.
- Persons, Stow. *The University of Iowa in the Twentieth Century: An Institutional History*. Iowa City: University of Iowa Press, 1990.
- Pessen, Edward. *Jacksonian America: Society, Personality, and Politics*. Homewood, IL: The Dorsey Press, 1969.
- Pessen, Edward, editor. *The many-faceted Jacksonian Era, New Interpretations*. Westport, CT: Greenwood Press, 1977.
- Petersen, William J. *The Story of Iowa: The Progress of an American State*. Volumes 1-2. New York: Lewis Historical Publishing Co., Inc., 1952.
- Petroski, Henry. *The Evolution of Useful Things*. New York: Alfred A. Knopf, 1992.
- Pickstone, John V. "Working Knowledge Before and After circa 1800: Practices and Disciplines in the History of Science, Technology, and Medicine." *Isis*, Vol. 98, No. 3 (September 2007), 489-516.

- Pritchett, H. S. "The Relation of Education Men to the State." *Science*, New Series, Vol. 12, No. 305 (Nov. 2, 1900), 658-660.
- Pursell, Carroll, editor. *A Companion to American Technology*. Malden, MA: Blackwell Publishing Ltd, 2005.
- Pursell, Carroll W. Jr., editor. *Technology in America: A history of Individual and Ideas*. Cambridge: The MIT Press, 1981.
- Raney, William Francis. *Wisconsin, A Story of Progress*. New York: Prentice-Hall, Inc., 1940.
- Rapp, William F. and Susan K. Beranek. *The Industrial Archaeology of Nebraska*. Crete, NE: J-B Publishing Company, 1984.
- Reingold, Nathan. *Science, American Style*. New Brunswick: Rutgers University Press, 1991.
- Reingold, Nathan, editor. *The Sciences in the American Context: New Perspectives*. Washington, D.C.: Smithsonian Institution Press, 1979.
- Reingold, Nathan, editor. *Science in America since 1820*. New York: Science History Publications, 1976.
- Reynolds, Terry S. "The Education of Engineers in America Before the Morrill Act of 1862." *History of Education Quarterly* (Spring 1993), 45-50.
- Reynolds, Terry S., editor. *The Engineer in America: A Historical Anthology From Technology and Culture*. Chicago: University of Chicago Press, 1991.
- Reynolds, Terry S. and Bruce E. Seely. "Striving for Balance: A Hundred Years of the American Society for Engineering Education." *Journal of Engineering Education*, Vol. 82, No. 3 (July 1993), 136-151.
- Rezneck, Samuel. *Education for a Technological Society, A Sesquicentennial History of Rensselaer Polytechnic Institute*. Troy, NY: Rensselaer Polytechnic Institute, 1968.
- Richardson, Heather Cox. *The Greatest Nation on Earth: Republican Economic Policies During the Civil War*. Cambridge: Harvard University Press, 1997.
- Ricketts, Palmer C. *History of Rensselaer Polytechnic Institute, 1824-1914*. New York: John Wiley & Sons, 1914.
- Rogers, Kenneth C. *Fundamental First: The Story of Stevens Institute of Technology*. New York: the Newcomen Society in North America, 1979.

- Rosenberg, Charles E. *No Other Gods: On Science and American Social Thought*, Revised and Expanded Edition. Baltimore: The Johns Hopkins University Press, 1997.
- Rosenberg, Nathan. *Technology and American Growth*. New York: Harper & Row Publishers, 1972.
- Rosentreter, Frederick M. *The Boundaries of the Campus, A History of the University of Wisconsin Extension Division, 1885-1945*. Madison: The University of Wisconsin Press, 1957.
- Ross, Earle D. *Democracy's College: The Land-Grant Movement in the Formative State*. New York: Arno Press and The New York Times, 1969.
- Ross, Earle D. "The Father of the Land-Grant College." *Agricultural History*, Vol. 12, No. 2 (April 1938), 151-186.
- Ross, Earle D. "The Great Triumvirate of Land-Grant Educators: Gilman, White, and Walker." *The Journal of Higher Education*, Vol. 32, No. 9 (December 1961), 480-488.
- Ross, Earle D. "The Manual Labor Experiment in the Land Grant College." *The Mississippi Valley Historical Review*, Vol. 21, No. 4 (March 1935), 513-528.
- Ross, Earle D. *The Land-Grant Idea at Iowa State College: A Centennial Trial Balance, 1858-1958*. Ames: Iowa State University Press, 1958.
- Ross, Earle D. *A History of The Iowa State College of Agriculture and Mechanic Arts*. Ames: The Iowa State University Press, 1942.
- Ross, James Baker. "Engineering Education at Iowa State College of Agriculture and Mechanic Arts, 1906-1920." (Masters Thesis, Iowa State University, 1978).
- Rudd, M. Eugene. "Science on the Great Plains: The History of Physics and Astronomy at the University of Nebraska-Lincoln" *University of Nebraska Studies*, New Series, No. 71. Lincoln: University of Nebraska, 1992.
- Rugg, Harold. *Culture and Education in America*. New York: Harcourt, Brace and Company, 1931.
- Sage, Leland L. *A History of Iowa*. Ames: Iowa State University Press, 1974.
- Sanders, Elizabeth. *Roots of Reform: Farmers, Workers, and the American State, 1877-1917*. Chicago: the University of Chicago Press, 1999.
- Schwieder, Dorothy. *Iowa, The Middle Land*. Ames: Iowa State University Press, 1996.

- Schwieder, Dorothy. *Patterns and Perspectives in Iowa History*. Ames: The Iowa State University Press, 1973.
- Schwieder, Dorothy and Gretchen Van Houten, editors. *A Sesquicentennial History of Iowa State University: Tradition and Transformation*. Ames: Iowa State University Press, 2007.
- Seaton, C.W. *Report on the Manufactures of the United States at the Tenth Census, June 1, 1880*. Washington: Government Printing Office, 1883.
- Seely, Bruce. "Research, Engineering, and Science in American Engineering Colleges: 1900-1960." *Technology and Culture*, Vol. 34, No. 2 (April, 1993), 344-386.
- Seely, Bruce. "SHOT, the History of Technology, and Engineering Education." *Technology and Culture*, Vol. 36, No. 4 (October, 1995), 739-772.
- Seller, Charles. *The Market Revolution: Jacksonian America, 1815-1846*. New York: Oxford University Press, 1991.
- Semi-Centennial Anniversary Book: The University of Nebraska 1869-1919*. Lincoln: By the University, 1919.
- Shambaugh, Benjamin F. *The Constitutions of Iowa*. Iowa City: The State Historical Society of Iowa, 1934.
- Shannon, Fred A. *The Farmer's Last Frontier, Agriculture, 1860-1897*. New York: Farrar & Rinehart, Inc., 1945.
- Shaw, Wilfred B., editor. *The University of Michigan, An Encyclopedic Survey*. Volume 1. Ann Arbor: University of Michigan Press, 1942.
- Simon, John Y. "The Politics of the Morrill Act." *Agricultural History*, Vol. 37 (April 1963), 102-112.
- Sinclair, Bruce. *A Centennial History of the American Society of Mechanical Engineers, 1880-1980*. Toronto: University of Toronto Press, 1980.
- Sinclair, Bruce. *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824-1865*. Baltimore: the Johns Hopkins University Press, 1974.
- Sinclair, Bruce, editor. *New Perspectives on Technology and American Culture*. Philadelphia: The American Philosophical Society, 1986.
- Singal, Daniel Joseph. *The War Within: From Victorian to Modernist Thought in the South, 1919-1945*. Chapel Hill: University of North Carolina Press, 1982.

- Siracusa, Carl. *A Mechanical People: Perceptions of the Industrial Order in Massachusetts 1815-1880*. Middletown, CT: Wesleyan University Press, 1979.
- Slotten, Hugh Richard. *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*. New York: Cambridge University Press, 1994.
- Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. New York: Random House, 1985.
- Smith, David C. *The First Century: A History of the University of Maine, 1865-1965*. Orono, ME: University of Maine at Orono Press, 1979.
- Smith, J. Allan. *The College of Agriculture of the University of Kentucky: Early and Middle Years, 1865-1951*. Lexington: The Kentucky Agricultural Experiment Station, 1981.
- Snow, C.P. *The Two Cultures: And a Second Look*. Cambridge: The University Press, 1965.
- Sommer, John W., editor. *The Academy in Crisis: the Political Economy of Higher Education*. London: Transaction Publishers, 1995.
- Stabile, Donald. *Prophets of Order*. Boston: South End Press, 1984.
- Stadtman, Verne A. *The University of California 1868-1968*. New York: McGraw-Hill Book Company, 1970.
- Stark, Jack. *The Wisconsin State Constitution, A Reference Guide*. Westport, CT: Greenwood Press, 1997.
- Starring, Charles R. and James O. Knauss. *The Michigan Search for Educational Standards*. Lansing: Michigan Historical Commission, 1869.
- Stott, Richard B. *Workers in the Metropolis: Class, Ethnicity, and Youth in Antebellum New York City*. Ithaca: Cornell University Press, 1990.
- Strachan, Robert Joe. "History of Engineering Drawing at the Iowa State University." (Master's Thesis, Iowa State University, 1961).
- Stratton, Julius A. and Loretta H. Mannix. *Mind and Hand: the Birth of MIT*. Cambridge: the MIT Press, 2005.
- Struik, Dirk J. *Yankee Science in the Making*. Boston: Little, Brown and Company, 1948.
- Tate, Michael L. *Nebraska History, An Annotated Bibliography*. Westport, CT: Greenwood Press, 1995.

- Thelen, David P. *The New Citizenship, Origins of Progressivism in Wisconsin, 1885-1900*. Columbia: University of Missouri Press, 1972.
- Thurston, Robert. "Apparatus Illustrating Mechanical Principles." *Journal of the Franklin Institute*, Vol. 92 (1871), 192-195.
- Thurston, Robert. "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872), 17-23.
- Thurston, Robert. "On the Necessity of a Mechanical Laboratory; its province and its method." *Journal of the Franklin Institute*, Vol. 100 (1875), 409-411.
- Thurston, Robert. "Technical Education in the United States: Its Social, Industrial, and Economic Relations to Our Progress." *Transactions, American Society of Mechanical Engineers*, Vol. 14 (1893), 855-1013.
- Thurston, Robert. "Engineering a Learned Profession." *Scientific American Supplement*, Vol. 38 (1894), 15467-15469.
- Thurston, Robert. "Industrial Education." *New York Daily Tribune*, 14 April 1897.
- Thurston, Robert. "On the Necessity of a Mechanical Laboratory; its province and its method." *Journal of the Franklin Institute*, Vol. 100 (1875), 409-418.
- Thurston, Robert. "Technical Training considered as a part of a 'complete and generous education'." *Scientific American Supplement*, Vol. 24 (1887), 9614-9616.
- Thurston, Robert. "The Improvement of the Steam Engine and the Education of Engineers." *Journal of the Franklin Institute*, Vol. 94 (1872), 17-25.
- Thurston, Robert. "The Needs and Opportunities of a Great Technical College." *Scientific American Supplement*, Vol. 36 (1893), 14586-14588.
- Thurston, Robert. "The New Education and the New Civilization—Their Unity." *Scientific American Supplement*, Vol. 34 (1892), 13825-13826.
- Thurston, Robert. "Engineering a Learned Profession." *Scientific American Supplement*, Vol. 38 (1894), 15469.
- Thurston, Robert. "Technical Education in the United States: Its social, industrial, and economic relations to our progress." *Transactions, American Society of Mechanical Engineers*, Vol. 14 (1893), 855-1013.
- Thurston, Robert. "The Mechanic Arts and Modern Education." *Scientific American Supplement*, No. 983 (November 3, 1894), 15704-15706.

- Thurston, Robert. "President's Inaugural Address." *Transactions of the American Society of Mechanical Engineers*, Vol. 1 (1880), 1-16.
- Thurston, Robert. "Engineering and the Professions in Education." *Science*, New Series, Vol. 9, Issue 220 (March 17, 1899), 407-409.
- Thurston, Robert. "The Modern Mechanical Laboratory, Especially as in process of evolution in America." *Sibley Journal* (1900), 331-358.
- Thurston, Robert. "American Industrial Education: What shall it be?" *Proceedings of the Society for the Promotion of Engineering Education Annual Meeting*, Vol. 8 (1900), 28-101.
- Thurston, Robert. "Proceedings of the Society for the Promotion of Engineering Education." *Science*, New Series, Vol. 13, No. 321 (February 22, 1901), 301-302.
- Thurston, Robert. "Educational Values and Our Liberality in Modern Educations." *Proceedings of the Society for the Promotion of Engineering Education Annual Meeting*, Vol. 11 (1903), 36-57.
- Tindall, George Brown with David E. Shi. *America, A Narrative History*, 3rd ed. New York: W.W. Norton & Co., 1992.
- Tobey, Ronald C. *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955*. Berkeley: University of California Press, 1981.
- Tobey, Ronald C. *The American Ideology of National Science 1919-1930*. Pittsburgh: University of Pittsburgh Press, 1971.
- Tocqueville, Alexis de. *Democracy in America*. New York: The Century Co., 1898.
- Trowbridge, William. *Inaugural Address before the Sheffield Scientific School of Yale College, October 5, 1870*. Philadelphia: Henry Carey Baird, Industrial Publisher, 1871.
- True, Alfred Charles. *A History of Agricultural Education in the United States, 1785-1925*. Washington, D.C.: United States Government Printing Office, 1929.
- Turner, Frederick Jackson. *History, Frontier, and Section, Three Essays*. Albuquerque: University of New Mexico Press, 1993.
- Uberoi, J.P.S. *Science and Culture*. Delhi: Oxford University Press, 1978.
- Veblen, Thorstein. *The Engineers and the Price System*. New York: The Viking Press, Inc., 1921.

- Veysey, Laurence R. *The Emergence of the American University*. Chicago: The University of Chicago Press, 1965.
- Waggoner, Paul E. "Research and Education in American Agriculture." *Agricultural History*, Vol. 50 (January 1976), 243-250.
- Walker, Francis A. and James Phinney Munroe. "Discussions in Education." New York: A. Holt Publishing, 1899.
- Walker, Francis A. *The Statistics of the Wealth and Industry of the United States from the Original Returns of the Ninth Census*. Washington: Government Printing Office, 1872.
- Wall, Joseph Frazier. *Iowa: A Bicentennial History*. New York: W.W. Norton & Company, 1978.
- Walsh, Margaret. *The Manufacturing Frontier, Pioneer Industry in Antebellum Wisconsin, 1830-1860*. Madison: State Historical Society of Wisconsin, 1972.
- Warner, Deborah Jean. "Science Education for Women in Antebellum American." *Isis*, Vol. 69, No. 1 (March, 1978), 58-67.
- Warren, S. Edward. *Notes on Polytechnic or Scientific Schools in the United States; Their nature, position, aims and wants*. New York: John Wiley and Son, 1866.
- Watson, Harry L. *Liberty and Power, The Politics of Jacksonian America*. New York: Hill and Wang, 1990.
- Webb, Walter Prescott. *The Great Plains*. Lincoln: University of Nebraska Press, 1959.
- Weisberger, Bernard A. *The New Industrial Society*. New York: John Wiley & Sons, 1969.
- Weiss, John Hubbel. *The Making of Technological Man: the Social Origins of French Engineering Education*. Cambridge: The MIT Press, 1982.
- Weller, L. David Jr. "A History of Undergraduate Teacher Education Programs at Iowa State University 1869-1968." (Ph.D. Dissertation, Iowa State University, 1975).
- Wesley, Edgar Bruce. *Proposed: The University of the United States*. Minneapolis: The University of Minnesota Press, 1936.
- White, Morton G. *A philosophy of culture: the scope of holistic pragmatism*. Princeton: Princeton University Press, 2002.
- White, Morton G. *Social thought in America, the revolt against formalism*. New York:

Viking Press, 1952.

- Widder, Keith R. *Michigan Agricultural College: The Evolution of a Land-Grant Philosophy, 1855-1925*. East Lansing: Michigan State University Press, 2005.
- Wiebe, Robert H. *The Search for Order, 1877-1920*. New York: Hill and Wang, 1967.
- Wilhite, Ann L. "Books, Bibles, and Boosters: Colleges on the Urban Frontier of Nebraska Territory (1854-1867)." (Masters Thesis, Creighton University, 1977).
- Williams, Roger, L. *The Origins of Federal Support For Higher Education: George W. Atherton and the Land-Grant College Movement*. University Park: The Pennsylvania State University Press, 1991.
- Winchell, N. H. "The State and Higher Education." *Science*, New Series, Vol. 2, No. 62 (Sept. 3, 1881), 413-416.
- Winters, Donald L. *Farmers Without Farms: Agricultural Tenancy in Nineteenth Century Iowa*. Westport, CT: Greenwood Press, 1978.
- Wisely, William H. *The American Civil Engineer 1852-1974: The history, traditions and development of the American Society of Civil Engineers*. New York: American Society of Civil Engineers, 1974.
- Wisely, William H. and Virginia Fairweather. *The American Civil Engineer 1852-1974, The history, traditions and development of the American Society of Civil Engineers*, Revised and Updated. New York: American Society of Civil Engineers, 2002.
- Woods, Thomas A. *Knights of the Plow: Oliver H. Kelley and the Origins of the Grange in Republican Ideology*. Ames: Iowa State University Press, 1991.
- Woodward, C.Vann. *Origins of the New South, 1877-1913*. Baton Rouge: Louisiana State University Press, 1971.
- Youmans, E.L. *The Culture Demanded by Modern Life: A series of addresses on the Claims of Scientific Education*. New York: D. Appleton & Co., 1867.
- Zimmerman, William David. "The Morrill Act and Liberal Education." *Liberal Education*, Vol. 50, No. 3 (1964), 395-401.
- Zussman, Robert. *Mechanics of the Middle Class: Work and Politics among American Engineers*. Berkeley: University of California Press, 1985.