J.B.M.

Vol. 17 No. 1

Journal of Business and Management

Editors
Cristina M. Giannantonio, Ph.D.
Amy E. Hurley-Hanson, Ph.D.

Published by Chapman University's Argyros School of Business and Economics
Sponsored by the Western Decision Sciences Institute

WESTERN DECISION SCIENCES INSTITUTE

The Western Decision Sciences Institute is a regional division of the Decision Sciences Institute. WDSI serves its interdisciplinary academic and business members primarily through the organization of an annual conference and the publication of the *Journal of Business and Management*. The conference and journal allow academicians and business professionals from all over the world to share information and research with respect to all aspects of education, business, and organizational decisions.

Journal of Business and Management

Volume 17, Number 1 2011

J.B.M.

Journal of Business and Management

We would like to thank the many ad hoc reviewers who shared their expertise to review the manuscripts submitted to JBM over the past few years. Their time and effort greatly contributed to the *Journal of Business and Management*.

David A. Buchanan
Cranfield University

Pearl Brewer
University of Nevada, Las Vegas

Russell W. Clayton
The University of Mississippi

Drew Dahl
Utah State University

Bruce Dehning
Chapman University

Susanna Fellman
University of Helsinki

Susan Flaherty
Towson University

Stephen Hartman
New York Institute of Technology

Andrew Hebdon
University of Mississippi

Steve Jaros
Southern University

Mark Johnson
Idaho State University

Karen M. Leonard
Indiana State University, Fort Wayne

Matthew McCarter
Chapman University

Björn Michaelis
University of Heidelberg

Nathan Ostreich
San Diego State University

Feraidoon Raafat
San Diego State University

James Rairdon
National Academy University

Bonnie Roach
Ohio University

Valerie Rosenblatt
University of Hawai'i at Manoa

Scott Safranski
Saint Louis University

Yusuf Sidani
American University of Beirut

Thomas W. Sloan
University of Massachusetts, Lowell

Yvonne Stedham
University of Nevada, Reno

Richard Sudek
Chapman University

Alexsey Tikhomirov
Binghamton University

Neharika Vohra
Indian Institute of Management, Ahmedabad

Ying Wang
Montana State University, Billings

Hong Zhu
Loyola University Maryland

Contents

Frederick Winslow Taylor: Reflections on the Relevance of *The Principles of Scientific Management* 100 Years Later

Cristina M. Giannantonio, Ph.D.
Chapman University

Amy E. Hurley-Hanson, Ph.D.
Chapman University

This Special Edition of the *Journal of Business and Management* was organized to celebrate the 100th anniversary of the publication of Frederick Winslow Taylor's *The Principles of Scientific Management*. The large response to our call for papers is indicative of the scholarly interest in Taylor, his work, and its relevance to management practitioners. The papers we received were broad in scope. While most were supportive of scientific management, some felt that Taylor should not be honored. The merits of Taylor's work can certainly be debated, but what cannot be argued is that Taylor changed the way people worked in the 20th century. This Special Issue focuses on the relevance of Taylor's work to managerial practice in the 21st century. The aim of this Special Issue is to encourage theoretical and empirical research on Taylor, *The Principles of Scientific Management*, and its implications for managerial practice in the 21st century.

Frederick W. Taylor, the father of Scientific Management, was an American mechanical engineer, efficiency expert, and management consultant. In 1911 he published his seminal work, *The Principles of Scientific Management*, in which he laid out the process of scientifically studying work to increase worker and organizational efficiency. The principles underlying his theory contributed to a wide array of management practices during the 20th century including task specialization, assembly line production practices, job analysis, work design, incentive schemes, person-job fit, and production quotas and control.

The impact of Taylor's work on the field of management has long been recognized by management scholars. Wren and Hay's (1977) study saw Taylor at the top of the list among contributors to American management thought and practice. Heames & Breland's (2010) study found Taylor to be at the top of their list thirty years later. *The Principles of Scientific Management*, not only tops Bedeian and Wren's (2001, p. 222) list of the 25 most influential management books of the 20th century, but they refer to it as "The most influential book on management ever published." The 100th anniversary of the publication of his book offers a unique opportunity to reflect on the relevance of Taylor's ideas in the 21st century.

This Special Issue has eight articles. The first paper, The Centennial of Frederick W. Taylor's The Principles of Scientific Management: A Retrospective Commentary, is by management scholar and historian Daniel A. Wren. Dr. Wren is the author of *The History of Management Thought*, now in its 5th edition, and *The Evolution of Management Thought*, with Arthur Bedian, also in its 6th edition. Wren received the Distinguished Educator Award from the national Academy of Management for his contributions "as the foremost management historian of his generation." Wren's paper describes the events leading to the publication of *The Principles of Scientific Management,* the evolution from task management to scientific management, and the factors that contributed to scientific management becoming an international force. Wren addresses "the intriguing question of why Taylor and his ideas have a continuing grip on management literature and our current thinking" (Wren, 2011, p. 11). The *Journal of Business and Management* is honored to have this noted management historian offer a retrospective commentary on Taylor's *The Principles of Scientific Management*.

Riccardo Giorgio Zuffo explores one aspect of the controversy surrounding Taylor's ideas in "Taylor is Dead, Hurray Taylor!" Zuffo details the criticisms of theorists who argued that Taylor's experiments were not positivist science, but instead, merely common sense. He then documents the scientific basis of Taylor's experiments and how his use of experiments both in and out of the lab led to the formulation of *The Principles of Scientific Management*. This paper also delves into the political, social, and ethical aspects of Taylor's work, exploring how Taylor's intentions were to create a better society by eliminating conflict using science.

Jeremy C. Short offers a novel perspective on the Taylor - Sinclair editorial debates that appeared in *The American Magazine*. In "The Debate Goes On! A Graphical Portrayal of the Sinclair-Taylor Editorial Dialogue," Short discusses how issues argued in the 1911 Taylor - Sinclair debate are still relevant today. In the same year that *The Principles of Scientific Management* was published, Taylor engaged in an editorial debate with Upton Sinclair, author of *The Jungle*. Upton's novel detailing horrific health and safety working conditions in the meat packing industry led to the establishment of the Food and Drug Administration. Upton Sinclair was critical of Taylor's methods, believing that scientific management exploited workers. Taylor believed that the implementation of scientific management would lead to improved working conditions for the workers. Short's paper highlights the impact Taylor's work had on the working conditions of employees in the 20th century and reminds us that work and the conditions under which it is performed have long been topics of scholarly and societal interest.

"Citing Taylor: Tracing Taylorism's Technical and Sociotechnical Duality through

Latent Semantic Analysis" by Nicholas Evangelopoulos offers further evidence that work performance is the subject of much scholarly interest. Evangelopoulos applies Latent Semantic Analysis to assess the intellectual territory that has been influenced by Taylor's ideas. His analysis found that research on Taylor fell into two streams: technical and sociotechnical. Evangelopoulos suggests that it is this inherent duality that assures Scientific Management of its continuing relevance in the 21st century.

John Paxton's paper focuses on a lesser known aspect of Taylor's contribution to manufacturing. "Taylor's Unsung Contribution: Making Interchangeable Parts Practical" details Taylor's work to produce interchangeable parts that were durable, reliable, and cost-efficient. Paxton explains how interchangeable parts were the foundation which allowed mass production to become a practical manufacturing reality. Paxton's paper reminds us that Taylor's training and experience as an industrial engineer influenced his interest in solving the problem of production machinery breakdowns. Taylor's role in making interchangeable parts economically feasible and the impact of this on manufacturing is thoroughly described in this paper.

Majula Salimath and Raymond Jones III discuss the scientific management of entrepreneurship. Their paper, "Scientific Entrepreneurial Management: Bricolage, Bootstrapping, and the Question for Efficiencies," argues that Taylor's principles of efficiency can be successfully applied in entrepreneurial firms and small businesses. Salimath and Jones describe the emerging field of scientific entrepreneurial management. The paper presents bricolage (making do with what is available) and bootstrapping (continuing operations without external finances or aid) as two techniques for managing resources. Salimath and Jones discuss the similarity of bricolage and bootstrapping to the resource management principles inherent in Scientific Management.

Marie Kulesza, Sheldon Friedman, and Pamela Weaver's paper, "Frederick Taylor's Presence in 21st Century Management Accounting Systems and Work Process Theories," examines the influence of Taylor's work on modern accounting systems. Their paper also examines Taylor's experiences working to design accounting systems suited to his clients' needs. Taylor's development of cost accounting systems closely paralleled the development of his ideas regarding worker efficiency. This paper offers strong evidence that Taylor's ideas are not limited to the field of Management, but are applicable across multiple functional areas of business (e.g. Accounting) in the 21st century.

The final paper in this Special Issue is by Linda Brennan. In "The Scientific Management of Information Overload," Brennan focuses on the applicability of Taylor's ideas to today's information workers. The paper considers how knowledge workers are faced with ever-increasing issues of information overload. Brennan offers a unique and thought-provoking analysis of the inefficiencies surrounding the management of information in the work place. Brennan argues that information, like other organizational resources, should not be wasted, and she offers several prescriptions for increasing efficiency in the office environment.

The papers included in this Special Issue of the *Journal of Business and Management* shed new light on Taylor's contributions to work and the conditions under which it is performed. The authors have provided strong arguments that the principles inherent in Scientific Management have continued relevance for the world of work in the 21st century. These papers also remind us of the importance of Santayana's quote: "Those who do not learn from history are doomed to repeat it." There is a continuous need for management theorists to remind us of the history behind our actions. Theories are applicable beyond the historical context they are created in. Just as Taylor's ideas of 100 years ago are germane to new contexts such as knowledge management, other historic theories can be applied to new and emerging contexts. Today's scholars may find that ideas once deemed obsolete present new ways to conceptualize modern managerial dilemmas. Because of the enormity of this Special Issue, it will be the *Journal of Business and Management's* only issue for 2011. We hope that the ideas presented here will allow Management scholars to reflect on Taylor's work in the next 100 years and we call for continued research on Frederick W. Taylor and *The Principles of Scientific Management*.

References

Bedeian, A.G. & Wren, D.A.(2001). Most Influential Management Books of the 20th Century. *Organizational Dynamics, 29*(3): 221-225.

Brennan, L.L. (2011). The Scientific Management of Information Overload. *Journal of Business and Management, 17*(1): 121-134.

Evangelopolous, N. (2011). Citing Taylor: Tracing Taylorism's Technical and Sociotechnical Duality through Latent Semantic Analysis. *Journal of Business and Management, 17*(1): 57-74.

Heames, J.T. & Breland, J.W. (2010). Management Pioneer Contributors: 30-Year Review. *Journal of Management History, 16*(4): 427-436.

Kulesza, M.G., Weaver, P.G. & Friedman, S. (2011). Frederick W. Taylor's Presence in 21st Century Management Accounting Systems and Work Process Theories. *Journal of Business and Management, 17*(1): 105-119.

Paxton, J. (2011). Taylor's Unsung Contribution: Making Interchangeable Parts Practical. *Journal of Business and Management, 17*(1): 75-83.

Salimath, M. (2011). Scientific Entrepreneurial Management: Bricolage, Bootstrapping, and the Quest for Efficiencies. *Journal of Business and Management, 17*(1): 85-104.

Short, J.C. (2011). The Debate Goes On! A Graphic Portrayal of the Sinclair-Taylor Editorial Dialogue. *Journal of Business and Management, 17*(1): 43-55.

Taylor, F.W. (1911). *The Principles of Scientific Management*. New York: Harper Brothers.

Wren, D.A. & Hay, R.D. (1977). Management Historians and Business Historians: Differing perceptions of pioneer contributions. *The Academy of Management Journal, 20*(3): 470-476.

Wren, D.A. (2011). The Centennial of Frederick W. Taylor's The Principles of Scientific Management: A Retrospective Commentary. *Journal of Business and Management, 17*(1): 11-22.

Zuffo, R.D. (2011). Taylor Is Dead, Hurray Taylor! The "Human Factor" in Scientific Management: Between Ethics, Scientific Psychology and Common Sense. *Journal of Business and Management, 17*(1): 23-41.

The Centennial of Frederick W. Taylor's *The Principles of Scientific Management*: A Retrospective Commentary

Daniel A. Wren

The centennial of The Principles of Scientific Management (PSM) provides an opportunity to reflect on Frederick W. Taylor's best known work. Taylor remains at the top of the list of those who have contributed to the history of management thought and PSM is considered the most influential management book of the 20th century. Those first attracted to the writings of Taylor were engineers who had seen his experiments and publications appear in the transactions of the American Society of Mechanical Engineers, who had read his first book, Shop Management. The events leading to the appearance of PSM are much lesser known and will be examined to aid in explaining how Taylor's preferred term for his work, task management, became scientific management. Finally, how scientific management became an international force, stimulating thought and development in numerous countries beyond the U.S will be discussed.

Would an author of today find a publisher for a book that advocated the conservation of our natural resources because "We can see our forests vanishing, our water-powers going to waste, our soil being carried by floods to the sea; and the end of our coal [and oil] and iron is in sight? But our larger wastes of human effort . . . is greater than from our material things, the one [natural resources] has stirred us deeply, while the other [human resources] has moved us but little" (Taylor, 1911, preface). These issues have many contemporary names, but our Nation and the World continue to encounter the problems of that period in which Frederick W. Taylor wrote those words. Taylor's solution was better management of our natural human resources and he provided ideas that still endure today.

The intriguing question is why Taylor and his ideas maintained a continuing grip on the management literature and our current thinking? One example illustrates how his influence continues. A contemporary, widely read U.S. business journal reported that Frederick W. Taylor was micromanaging a gift of $10,000,000 to the Stevens Institute of Technology in Hoboken, New Jersey. According to this article, Taylor, though dead for eight decades, provided in his will for how this endowment was to be invested and how funds could be spent. In this way, Taylor was allegedly exerting control over his money long after his death. The article was entirely false -- except for the correct spelling of Taylor's name -- and also provided the correct $10,000,000 figure. Taylor's will (he died in 1915) and the will of his widow, Louise Taylor (who died in 1949), mentioned no gift to Stevens. The idea that Taylor was managing from his grave would catch the attention of a contemporary reader, but in actuality, was totally inaccurate. The reality was that the Stevens Institute of Technology had received a gift of $10,000,000 from Robert P.A. Taylor in memory of Frederick W. Taylor. Fred and Louise Taylor adopted three children who were orphaned by a tragedy that simultaneously took the lives of their parents, relatives of Mrs. Taylor. Robert Taylor became an extremely successful investment broker and, upon his death, made this gift to his Father's alma mater; the specific instructions on managing the money came from Robert, the investment counselor, not from Frederick W. Taylor (*Business Week*, May 15, 1995, p. 34).

Surveys of scholars in the Academy of Management, the Business History Conference, and the Management History Division of the Academy of Management over three decades have consistently ranked Frederick Taylor as the most influential person in management and business history (Heames & Breland, 2010; Wren & Hay, 1977). Another survey of management scholars named Taylor's *Principles of Scientific Management* as the most influential book of the 20th century (Bedeian & Wren, 2001). This continuing reference to the importance of Taylor and his ideas merits a further examination of his life, ideas, and influence.

Taylor's ideas have not survived unchanged, but his work has inspired study in other disciplines and has been refined by the addition of new information generated in the hundred years since the publication of *The Principles of Scientific Management*. The history of management thought has evolved, presenting the opportunity for us to have a diverse set of tools and techniques for being better managers. But Taylor provided beginning points that have enabled us to extend our thinking. It is important to see him as furthering the search for improving management that began with a set of ideas beginning to form in the latter part of the 19th century. Joseph Litterer called the formation of these ideas "systematic management" and the need to find improved work methods, scheduling of work, more effective incentives, and the ability to produce more efficiently (Litterer, 1961). These ideas were loosely connected, lacking a focal point and someone to pull these ideas together and provide a voice for managing more efficiently.

Early Life and Career

Biographical information about Taylor is readily available (Copley, 1923; Kanigel, 1997; Wrege & Greenwood, 1991; Wren & Bedeian, 2009, 121-155) so a summary should be sufficient in this discussion of him. Frederick Taylor lived in relative luxury from his birth, March 20, 1856, until his death on March 21, 1915. His father, Franklin Taylor, was a lawyer who practiced briefly but had inherited wealth. Taylor Sr. added to that with ownership of a large number of farms and properties in and around Philadelphia, Pennsylvania. Frederick's mother, born Emily Winslow, was of the Delano family, as was Franklin Delano Roosevelt, who later became President of the United States. Emily was a vocal proponent of women's rights and a vigorous opponent of slavery. Later we will suggest the influence Taylor's mother's had on his formation of work groups at Midvale Steel.

He was expected to go to Harvard to become a lawyer, passed the entrance exams with honors, but shortly thereafter, began to have headaches and eye problems. There was concern that studies at Harvard might further injure his health, so he by-passed legal studies to go to work as an apprentice pattern maker at Enterprise Hydraulic Works, then as a worker at Midvale Steel where he would rise rapidly to become chief engineer for the firm of William Sellers. Sellers encouraged Taylor to experiment with the techniques of shop management and for twelve years he would study machine belting, steel tools for cutting metals, and how the workers would give less than they could, a behavior Taylor called "soldiering." He was not the first person to find this restriction of output, but his curiosity was aroused when it came to how he might improve working conditions so the workers would improve their performance. This was the beginning of his use of time study to set performance standards and the idea of a differential piece-rate incentive plan that paid ordinary wages for making the output standard and higher wages for performance above the minimum.

He felt it was management's responsibility to find the proper tools, plan the assignment of work, and provide instructions that would enable workers to earn the performance bonus. Taylor was an engineer, receiving his bachelor's degree in Mechanical Engineering at the Stevens Institute of Technology in 1883, but he felt there was a need for scientific study "of the motives that influence men" (Taylor, 1911, p. 119). His training did not enable him to be a behavioral scientist to study motivation, but he felt that monetary incentives, given after a task had been properly determined and studied, would overcome soldiering.

At Midvale Steel, the workers formed groups according to their ethnic background: Polish workers preferred to work with others from Poland, Germans with other Germans, and so on. Taylor felt these cliques were not appropriate for everyone working together, so he broke up the ethnic work groups "by hiring African-Americans and distributing them among existing work teams" (Dawson, 2004, p. 236). This practice was the first to overcome the racial bias in Philadelphia machine shops and perhaps was influenced by Taylor's mother's stance for integrating African-Americans into work places and society.

The Engineer as an Economist

In 1880 the American Society of Mechanical Engineers (ASME) was founded. Taylor joined in 1886. He was in attendance when Henry R. Towne, President of the Yale and Towne Manufacturing Company, presented a paper on "The Engineer as an Economist." Towne (1886, pp. 428-429) observed that:

> "there are many good mechanical engineers: there are also many good 'businessmen'; but the two are rarely combined in one person. But, this combination of qualities ... is essential to the management of industrial works, and has its highest effectiveness if united in one person... the matter of shop management is of equal importance with that of engineering... and the *management of works* has become a matter of such great and far-reaching importance as perhaps to justify its classification also as one of the modern arts . . . [and] essential to the efficient management of the business, and especially to increased economy of production".

Since no other engineering group appeared to be concerned with management, Towne proposed that the ASME create an "Economic Section" to act as a forum for "shop management" and "shop accounting."

Shop management would deal with the subjects of organization, responsibility, reports, and all that pertained to the "executive management" of works, mills, and factories. "Shop accounting" would treat the question of time and wage systems, determination and allocation of costs, methods of bookkeeping, and all matters that pertained to manufacturing accounts. Thus, a body of literature could be developed, existing experience could be recorded, and the ASME could provide for an interchange of ideas about management. Towne's paper was a significant turning point in the development of management thinking because of his recognition that factories needed engineers who would think in economic terms of efficiency.

Towne's paper encouraged Taylor to think beyond technical and engineering problems and to turn his attention to shop management. Taylor drew upon his experiences at Midvale Steel and presented a paper to his fellow engineers on "rate-fixing" (i.e. setting standards) and piece rate incentives. His position was that once the time to perform a task was known and the amount of output that could be produced in a day was determined, the issue became getting the worker to produce at that level and not restrict output. Taylor was chagrined to find that in the following discussion his colleagues focused on incentives and not on setting the rate — Taylor felt that incentives were meaningless unless the standard had been determined (Taylor, 1895).

Taylor's interest in the economical use of resources led to his first book, *Shop Management* (Taylor, 1903). Originally a paper presented to ASME members, *Shop Management* contained many ideas that he would refer to in his papers, books, and presentations: time study to eliminate wasted motions and to set an appropriate standard of performance ("rate-fixing"); pay for performance through a "differential piece rate" which he adopted from Midvale's prior practice; functional foremen; management by exception; worker selection and training; mutual accident insurance, with the cost shared by the employer and the worker, restriction of output by workers ("soldiering"); and the mutual interests between workers, who wanted high wages, and the manufacturers, who wanted low costs, both being attainable through Taylor's task management. *Shop Management* was a handbook for managers, not an academic presentation, and placed the responsibility on management to do a better job of setting standards, selecting and training, providing incentives, and recognizing the shared interests they had with their employees.

Increasing Recognition for Taylor

Taylor's reputation among engineers in the United States, Europe, Great Britain, and Japan was well established from his publications and experiments on belting, shoveling, high speed steel-cutting tools at Midvale Steel and loading 'pig-iron' later as a consultant at Bethlehem Steel. He attracted a number of followers such as Henry L. Gantt, Horace King Hathaway, Morris Cooke, Sanford Thompson, and Carl Barth to whom he would typically give consulting assignments and he became more of a 'consultant's- consultant.' Daniel Nelson traced the work of his disciples and found "general adherence to Taylor's ideas" and a "strong positive correlation" between the installation of his ideas and improved efficiency (Nelson, 1974, p. 500). Harvard Professor C. Bertrand Thompson also studied 113 applications of Taylor's ideas: of those, 59 were complete successes; 20 were partially successful; and 34 were failures which Thompson attributed "to the personality of the consulting engineers . . . and the personality of the managements" (Thompson, 1917, p. 13). None of the failures were due to workers' shortcomings.

Taylor became President of the ASME in 1906 and was coaxed into lecturing on his ideas at Harvard University's Graduate School of Business Administration by its first dean, Edwin Gay. His lectures were given each winter semester from 1909 to 1914. For a brief period, Bertrand Thompson arranged Taylor's presentations and would later set up his own consulting firm following Taylor's ideas with some modifications to allow for the engrained power of trade unions, in France and other parts of Europe.

It was not all work and no play for Taylor: he landscaped the family home at Boxly near Philadelphia, experimented with soil mixtures to improve golf greens, designed golf clubs, including a "Y" shaped putter, and teamed with his brother-in-law, Clarence M. Clark, to win the U.S. Lawn Tennis Association's amateur lawn tennis championship in 1881 (Taylor & Bedeian, 2007).

How Management Became "Scientific"

Taylor's reputation among industrial engineers was growing and the successful consulting assignments by him and his colleagues would bring an unusual twist in the course of management history. In 1910, a collection of railroads operating north of the Potomac and Ohio rivers and east of the Mississippi river petitioned the Interstate Commerce Commission for a rate increase on freight shipped. Their appeal to the commission became known as the Eastern Rate Case and it would have long-range implications for Taylor's ideas. The shippers hired Louis D. Brandeis, known as the "people's lawyer" for accepting controversial cases, to represent them. Brandeis searched for information to present his case and met with Frank Gilbreth, Henry V.R. Scheel of Brighton Mills, Henry L. Gantt, and Robert T. Kent, editor of the *Industrial*

Engineering Magazine to discuss the shippers' case. At this time, Taylor's work was referred to as "task management," the "Taylor System," or "modern methods of management," but no one label was universally used. Brandeis noted Taylor often used "scientific" in his writing and those in attendance agreed this would be a good description of what Taylor sought.

In the Interstate Commerce Commission hearings, Brandeis argued that the railroads were only seeking profits, had disregarded operations costs, and would be more efficient if they used "scientific management." He called as witnesses individuals who had installed Taylor's system in their workplaces; James M. Dodge provided testimony about the successes at the Link-Belt Company; H. K. Hathaway gave evidence of the improvements at Tabor Manufacturing. However, it was Harrington Emerson who gave the most sensational testimony. Emerson had been a consultant on the Atchison, Topeka, and Santa Fe Railroad, and had compared their costs with those of other railroads. He concluded it was possible for the railroads to save $300 million a year, with $240 million coming from labor costs (*Evidence Taken by the Interstate Commerce Commission*, 1911).

Emerson's testimony made newspaper headlines as "one million dollars a day" and "scientific management" became the phrase for management to cut costs and yield savings to consumers. A railroad historian, Albro Martin, wrote the basis of Emerson's testimony was his claim that railroad workers were typically five percent inefficient and, if $240 million came from savings on labor, one-third of all railway workers would be eliminated (Martin, 1971, pp. 213-219). The ICC denied the railroads' request for a rate increase and Louis Brandeis added to a reputation that would lead him to become an Associate Justice of the U.S. Supreme Court. When Taylor, was asked about Emerson's testimony, he replied: "I believe we can save a million dollars a day, just as he said we can, but the reports of these hearings in Washington were not quite fair enough to say that it can't be done all at once. It would take four or five years" (Taylor, 1911, pp. 256-257).

Taylor preferred the phrase "task management," fearing "scientific management" sounded too academic. After 1911 and the Eastern Rate case, what might have been "Principles of Task Management" would take on a new identity. It is speculative of course, but Taylor might have endured less criticism if Brandeis had not coined "scientific management" and painted a bulls-eye on Taylor's work.

Emerson's testimony led to publicity for the new label, scientific management, and aroused the ire of the railway brotherhoods, which had a great deal to lose if the railroads eliminated numerous jobs of porters, engineers, brakemen, and others who were on the trains themselves. In shops where trains were repaired or refitted, the International Association of Machinists represented those workers and they too would have been affected by the recommended layoffs.

Before the Eastern Rate Case, General William Crozier, Head of U.S. Ordinance, was in contact with Taylor about the sloppy management of the military arsenals. The arsenals at Watertown, New York, and Rock Island, Illinois, were chosen for initial study. In 1908, Colonel Frank Hobbs, eager to undertake the plan to improve performance at the Rock Island Arsenal, independently assigned the task of time study to his officers, although none of them were trained in this work and the machinists were not told why they were being timed. The workers protested to their congressional representatives and General Crozier immediately ordered Hobbs to cease timing the workers (Nelson, 1980).

At the Watertown Arsenal, Taylor advised Crozier to proceed cautiously and sent Carl Barth to prepare the workers, including seeking their ideas about being timed on the job. Dwight Merrick, sent to assist Barth, began time study regardless of Taylor's instructions. The first worker Merrick attempted to time refused to continue his work and was discharged by Colonel Charles Wheeler, the commanding officer. The remaining workers went on strike August 1911; this was the first strike under Taylor's task management (Copley, 1923, p. 344). The machinists union petitioned Congress to investigate the mistreatment of Watertown's workers.

The Congressional Investigation began in October 1911 and lasted until February 1912 (*Hearings before the Special Committee of the House of Representatives,* 1912). After months of hearings and the testimony of numerous witnesses, the investigating committee found no fault with Taylor's system or any others; no evidence was offered of abuse to workers and there was no need for remedial legislation (Wren & Bedeian, 2009). The investigation occurred, however, as *The Principles of Scientific Management* was in the process of being published.

The Principles of Scientific Management

In 1907, Taylor began to invite those who were interested in his ideas to come to his home, "Boxly," in Chestnut Hill, a suburb of Philadelphia, where he would lecture on his system. These lectures were well attended and Morris L. Cooke, a disciple of Taylor, employed a stenographer to record Taylor's talks which Cooke would edit. Cooke's intent was to publish a polished version of Taylor's Boxly talks as a book, originally entitled *Industrial Management* (Wrege, 2008). After studying the lecture, Cooke advised Taylor that he should change the tone of his talks to make them sound less dictatorial, and to reduce the amount of time spent talking about slide rules (15 minutes) and pig-iron handling and shoveling (1.5 hours) (Taylor, 2008).

By 1908, the ASME began to forget Henry Towne's plea about the engineer as an economist and began to define their mission in a more narrow fashion. For example, the ASME declined to join the Conservation League of America, the League of Good Roads, and rejected Morris Cooke's proposal that engineers should be concerned with smoke abatement in industry (Calvert, 1967).

Taylor was President of the ASME in 1906 but an increasing number of the members did not like the direction he was taking regarding efficiency, management, and the conservation of resources. After the Eastern Rate Case and the Brandeis-coined phrase, scientific management, ASME members who were affiliated with the railroads objected, especially to Harrington Emerson's claim of $1,000,000 a day savings if the railroads adopted scientific management. Taylor wanted the ASME to recognize his "scientific management" as based on scientific laws (Layton, 1971, pp. 140-141).

By 1910, Taylor was ready to publish *The Principles of Scientific Management* though it has been alleged that Taylor plagiarized 69 pages of Cooke's *Industrial Management* to use in his work. Plagiarism is a serious charge therefore, some explanation is needed. Taylor offered to give the royalties to Cooke if *Principles* interfered with the sales of Industrial Management but Cooke declined. In the manuscript for Industrial Management, in Cooke's handwriting, he wrote that Chapter 2 (the one allegedly plagiarized) "is very largely a recital of Mr. Taylor's personal experiences in the development of scientific management, and as such has been written by himself in the first person" (Wrege & Stotka, 1978, pp. 746-747). Cooke edited and polished Taylor's Boxly talks which provided a portion of what became *The Principles of Scientific Management*.

The archives of Harper & Brothers, publishers of *The Principles of Scientific Management,* indicate that Taylor assigned over $3,200 in royalties to Cooke from June 1911 (the month *PSM* was published until the last quarter of 1913) (Archives of Harper & Brothers, 1982). It seems reasonable to conclude that Cooke, and possibly others, contributed to, but did not actually write *PSM*. Cooke took Taylor's Boxly talks, edited and enriched them and received the royalties for his work. The fact that *PSM* took many different published appearances suggests further evidence that the ideas were Taylor's.

Appearances before Final Publication of The Principles of Scientific Management

Taylor submitted his paper to the ASME for publication but, after a year-long delay, it was rejected by the publications committee. Taylor's determinations to have his work reach a wider audience and to overcome the ASME's rejection led to numerous appearances. First, Taylor distributed a private printing of *PSM* in February 1911 "for confidential circulation among the members of the American Society of Mechanical Engineers with the compliments of the author" (Taylor, 1911, p. 118).

This was followed in March, April, and May 1911 when the *American Magazine* published Taylor's book as *The Gospel of Efficiency*, with various subtitles. It included pictures of Taylor, Taylor's mother (Emily Winslow Taylor), the Taylor home at Chestnut Hill, Gantt, Dean Gay of Harvard University, Barth, Emerson, Cooke, and numerous others associated with Taylor's work. One unusual set of photographs appeared of Frank Gilbreth's bricklayers in before and after positions in applying scientific management. The *American Magazine* had a following in the general public and Taylor intended to spread the gospel as far as possible.

The *Journal of Accountancy* published *The Principles of Scientific Management* in a two-part series, May and July of 1911, based on an unedited, extemporaneous address before the Civic Forum in New York on April 28, 1911. This abbreviated version presented many of Taylor's ideas, but omitted any reference to Taylor's familiar example of 'pig-iron' handling and shoveling. Taylor had been tutored in accounting and one component of his management system aimed at reducing production costs. He also had a large following of accountants who were interested in scientific management. Others, such as Louis Brandeis, Alexander Hamilton Church, Frank Gilbreth, and Henry L. Gantt also published articles in the *Journal of Accountancy* about industrial efficiency and scientific management.

The Civic Forum presentation in New York city was another opportunity for Taylor to carry his message of better management to the public and those in corporate executive positions. This speech focused on the problems of restricted output and the influence of unions; the new responsibilities of management and how these new scientific management duties would increase output (Taylor, 1911, pp. 117-124; Taylor, 1911, pp. 181-188). Carol Dean concluded these presentations of *The Principles of Scientific Management* were altered slightly because of the target audience and limits on time or journal space, but the message remained the same.

Another tailored version was presented at the Dartmouth College as part of a book titled *Scientific Management: Dartmouth College Conferences*. This version presented many of Taylor's earlier anecdotes, but added the work of a surgeon and how an apprentice would be trained (Taylor, 1912, p. 54). Frank Gilbreth did numerous studies of surgical procedures and Taylor had frequently used surgery as one of his teaching examples. At this time, Taylor and Gilbreth had not had their serious disagreement over work that Gilbreth was doing for a firm in Germany.

Conclusion

Within two years of its 1911 publication, *PSM* was translated into French, German, Dutch, Swedish, Russian, Italian, and Japanese. Taylor's early work, *Shop Management,* appealed to engineers, but *PSM* appealed to a broader audience in the U.S., Europe, and Japan. The message was global, calling for the improved utilization and conservation of human and physical resources. It is important to see Taylor in the context of his era, an era of needed reform and progressive management in industry, arsenals, naval ship yards, government, and education. One measure of Taylor's impact as an example of this need was in collegiate education. Nelson identified 21 colleges and universities that offered a course in scientific management in colleges of business or engineering by 1920 (Nelson, 1992, p. 83).

Taylor's ideas traveled to Europe, but with varied success. In England, scientific management was not held in high esteem (Whitson, 1997, pp. 207-209). In France, Henry Le Chatelier and Charles de Freminville translated and promoted Taylor's writings and became leading individuals in the acceptance of scientific management; but in Germany, the Germans adopted their own brand of work study that approximated Taylor's work (Devinat, 1927; Thompson, 1940). Japan was emerging from its agrarian history into the industrial age and scientific management found fertile soil for its study and application (Taira, 1970). Yukinori Hoshino translated *PSM* into Japanese in 1912 and Yoichi Ueno carried those ideas forward (Greenwood, Greenwood & Ross, 1981).

In the U.S.S.R., Lenin approved of more work, but not always what Taylor had envisioned as a product of work study and improvement. "Stakhanovites" became heroes and won medals because they were the high producers (Bedeian & Phillips, 1990) and production goals were set by the Communist leaders regardless of worker capabilities (Wren & Bedeian, 2004). Henry L. Gantt's method of charting formed the basis for Soviet five-year plans through one of Gantt's followers, Walter N. Polakov (Wren, 1980).

One hundred years later *Principles of Scientific Management* remains a lasting contribution to the development of management thought. Taylor continues to dominate any list of persons who have made business management a worthy calling and a fitting topic to study. His reach was international and to a broad spectrum of audiences and his ideas shaped how we live and think today.

References

Archives of Harper & Brothers (1817-1914). Reels 31 and 32 of microfilm published by permission of Harper & Row and the Butler Library of Columbia University Library. Index compiled by Christopher Feeney, Cambridge University Press, 1982, 590, 762 of the ledger provided courtesy of Carol Carlson (Dean) Gunn.

Bedeian, A.G. & Wren, D.A. (2001). Most influential books of the Twentieth Century, *Organizational Dynamics, 29* (3): 63-84.

Bedeian, A.G. & Phillips, C.R. (1990). Scientific Management and Stakhanovism in the Soviet Union: A Historical Perspective, *International Journal of Social Economics, 17*: 28-35.

Calvert, M.A. (1967). *The Mechanical Engineer in America, 1830-1910: Professional Cultures in Conflict*, Baltimore: Johns Hopkins University Press.

Copley, F.B. (1923). *Frederick W. Taylor: The Father of Scientific Management*, New York: Harper & Brothers.

Dawson, A. (2004). *Lives of Philadelphia Engineers: Capital, Class, and Revolution, 1830-1890*, Aldershot, England: Ashgate Publishers.

Dean, C.C. (1997). The Principles of Scientific Management by Fred Taylor: Exposures in print beyond the private printing, *Journal of Management History, 3*: 4-17.

Devinat, P. (1927). *Scientific Management in Europe*, Geneva: International Labor Office

Greenwood, R.G., Greenwood, R.A. & Ross (1981). Yoichi Ueno: A Brief History of Japanese Management, 1911 to World War II, in K.H. Chung (ed.), *Proceedings of the Annual Academy of Management Meetings*: 107-110.

Heames, J.T. & Breland, J.W. (2010). Managements pioneer contributors: 30-Year review, *Journal of Management History, 16* (4): 427-436.

Hearings before the Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management (1912), under authority of House Resolution 90, Washington, D.C.: U.S. Government Printing Office.

Kanigel, R. (1997). *The One Best Way: Frederick W. Taylor and the Enigma of Efficiency,* New York: Viking.

Layton, Edwin T. Jr. (1971). *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession,* Cleveland: Case Western Reserve University Press.

Litterer, J.A. (1961). Systematic management: The search for order and integration, *Business History Review, 35*: 461-476.

Martin, A. (1971). *Enterprise Denied: Origins of the Decline of American Railroads, 1897-1917*, New York: Columbia University Press.

Micromanaging from the Grave (May 15, 1995), *Business Week*: 34.

Nelson, D. (1974). Scientific management, systematic management, and labor, 1880-1915, *Business History Review, 48*: 479-500.

Nelson, D. (1980). *Frederick W. Taylor and the Rise of Scientific Management,* Madison, WI: University of Wisconsin Press.

Nelson, D. (1992). Scientific management and the transformation of university business education. In Nelson, D. (Ed.), *A Mental Revolution: Scientific Management since Taylor*, Columbus, OH: Ohio State University Press, 1992: 77-101.

Taira, K. (1970). Factory legislation and management modernization during Japan's industrialization, 1886-1916. *Business History Review, 44*: 84-109.

Taylor, Frederick W. (1903). *Shop Management,* New York: Harper & Row.

Taylor, Frederick W. (1911). The gospel of efficiency: the new science of business management, *American Magazine, 71*: 563-581.

Taylor, Frederick (1911). The Principles of Scientific Management, *American Magazine 71*: 785-793.

Taylor, Frederick (1911). The Principles of Scientific Management, *American Magazine 71*: 101-113.

Taylor, Frederick W. (1911). Scientific Management: Principles and Methods, *Journal of Accountancy, 12*: 117-124.

Taylor, Frederick W. (1911). Scientific Management: Principles and Methods, Part II, *Journal of Accountancy, 12*: 181-188.

Taylor, Frederick W. (1911). *The Principles of Scientific Management,* New York: Harper and Brothers.

Taylor, Frederick W. (January 14, 1911). The Conservation of Human Effort, address to the Philadelphia Club, Taylor Collection. Reprinted in T. Sasaki & D.A. Wren (Eds.), *Taylor and His Comrades,* London: Pickering & Chatto, Series 2, Vol. 2: 256-257.

Taylor, Frederick W. (1912). The Principles of Scientific Management, *Addresses and Discussions at the Conference on Scientific Management held October 12, 13, 14, Nineteen Hundred and Eleven,* Hanover, NH: Amos Tuck School of Administration and Finance, Dartmouth College: 22-55.

Taylor, Frederick W. (2008). A report of a lecture and questions put to Mr. Taylor: a transcript, *Journal of Management History, 14*: 214-236.

Taylor, S.G. & Bedeian, A.G. (2007). From boardroom to bunker: how Fred Taylor changed the game of golf forever, *Management & Organizational History, 2*: 195-218.

Thompson, C.B. (1917). *The Theory and Practice of Scientific Management*, Boston: Houghton Mifflin.

Thompson, C.B. (1940). The Taylor system in Europe, *Advanced Management, 5*(4): 172-176.Towne, H.R. (1886). The Engineer as an Economist, *Transactions*, ASME, 7: 428-432.

Whitson, K. (1997). The reception of scientific management by British engineers, 1890-1940, *Business History Review, 71*: 207-229.

Wrege, C.D. & Greenwood, R.G. (1991). *Frederick W. Taylor, the Father of Scientific Management: Myth and Reality*, Homewood, IL: Business One Irwin.

Wrege, C.D. & Stotka, A.M. (1978). Cooke creates a classic: the story behind F.W. Taylor's Principles of Scientific Management, *Academy of Management Review, 3*: 736-749.

Wrege, C.D. (2008), F.W. Taylor's Lectures on Management, June 4, 1907, *Journal of Management History, 14*: 209-213.

Wren, D.A. (1980). Scientific management in the U.S.S.R., with particular reference to the work of Walter N. Polakov, *Academy of Management Review, 5*: 1-11.

Wren, D.A. & Bedeian, A.G. (2004). The Taylorization of Lenin: Rhetoric or reality? *International Journal of Social Economics, 31*: 287-299.

Wren, D.A. & Hay, R.D. (1977). Management historians and business historians:

differing perceptions of pioneering contributions, *Academy of Management Journal, 20*: 470-475.

Wren, D.A. & Bedeian, A.G. (2009). *The Evolution of Management Thought 6th ed.* New York: John Wiley & Sons.

Taylor is Dead, Hurray Taylor! The "Human Factor" in Scientific Management: Between Ethics, Scientific Psychology and Common Sense

Riccardo Giorgio Zuffo
University "G. d'Annunzio" of Chieti

Approximately one hundred years after the historical insights of Adam Smith on the division of labor (1776) as a determining factor in value creation (Taylor, 1911), the first conceptions of modern industry and what would come to be known as Scientific Management were born. The incubation period had been long. But, in 1879, Taylor, at twenty-three, was hired at the Midvale Steel Company where he progressively deduced and outlined those principles, models, and ideologies that would go on to influence production and the way to "live" their work, and reconfigure their daily life for an entire century. Now, a century later, life is full of great promise and many changes and by rereading Taylor's works contextually to the "Progressive Era" (Gould, 2000), they assume the paradigmatic value of a broader debate (Nelson, 1975, 1980), concerning what extent his work and action can be in some way rediscovered and focalized.

With Taylor, work had evolved in a way so as to permit the social and economic emancipation of millions of men. However, in order to fully understand Taylor's centrality for work it is necessary to first overcome the personal and the ideological dimensions that have made Taylorism both a symbol of labor's oppression, and a beacon of mankind's well-being. The history and chronicle of the 20th century has considered Taylor in many ways an engineer, a technocrat, a rationalist, a great hero and benefactor of humanity, an emblem of ferocious capitalism and of the modern factory's alienation. But Taylor was also genial, curious, and dogmatic; irascible, arrogant, and condescending; ambitious wealthy, sophisticated, aristocratic, and famous. He was a friend of presidents and ministers. He also had a wide audience due to his newspaper contributions (Copley, 1923; Kanigel, 1997; Nelson, 1975). Lastly, he was political, favoring Roosevelt in the 1901 elections (Taylor, 1911). Taylor was certainly a complex and ambiguous figure, but above all, he was an expression of his time.

Taylor was born the idealistic and enlightened son of the educated bourgeoisie that characterized America during the Progressive Era (Sasso, 1984; Rossi, 1988, 1995). As did many other industrialists, academics and scholars who supported the belief in the modern age, he also took part in the building and shaping of America's greatness (Nelson, 1975; Gould, 2000). Taylor was the Zeitgeist of his time: his life and his action were metaphors of an epochal change. Therefore, it is difficult to condense his contribution which was defined within its rapport with differing thematic areas to that which he contributed and confronted with obsession and excellence. Certainly Taylor, in relation to the historical developments of applied psychology, was the first scholar to recognize the "human factor" as scientific management's central aspect both as a factor to be evaluated and understood scientifically and also as a factor with rich and complex political, social, ethical, and economic implications (Münsterberg, 1913; De Masi, 1992). The scientific aspects of work and man at work, as social subjects, coexisted. The factual and the ideal man together, became the fundamental factor for the growth of United States and the new concepts of labor during the 19th century.

Scientific Aspects of Taylor's Scientific Management

His model was one where techniques (today we would say technologies) of product, processes, machines and tools, along with working methods and control systems, were in a systematic equilibrium with the workers. The human element, as a central component in Taylor's conception, is in its rapport with the factors outlined here.

The first is relative to the model of scientific management that Taylor implemented in his daily practice, combining factors considered scientific or scientifically plausible, and factors where science had yet to enter, such as common sense, trade practices, and folk psychology.

Taylor gradually developed his theory of scientific management by aggregating a disperse and fractal understanding while he began to outline, which is typical of fast and fluid historical periods such as the period of industrialization. Taylor's main objective was to pursue a scientific model or rather, to "search for scientific truth," by outlining certainties and gradually improving on his first approximations. These approximations, sometimes called sophistries (Nelson, 1975; Kanigel, 1997), cunning and often "careful communication," were the consequence of the impossibility to perform his studies in a laboratory context. Taylor needed to work in *corpore vivo*, in the concrete reality of the factories: approximations to gradually overcome in favor of more scientific reconfigurations. This kind of hybrid, incomplete or intuited knowledge became the theoretical path for many disciplines in the following decades, such as the psychology of work and organizations, sociology, management, and organizational behavior studies, for which Taylor was the appropriate model, frame, and support (Kaneklin, 2004).

Confronting a time of knowledge specialization, and the continuous emergence of new and useful disciplines and subdisciplines, Taylor developed his system in order to reconfigure a global theory of understanding focused on production factors. Although it may be related to the emergence of other technical disciplines of the 19th century, scientific management is still a recent concept when compared to medicine, mechanics, physiology, and engineering. Nonetheless, it is a complex concept, characterized by multidisciplinary aspects and sustained by insights and common sense psychology, (as well as by more scientific theory fragments) that all merge together into a sort of 'bricolage.' In other words, a fluid intelligence with the capacity to think logically and solve problems in novel situations, independently from acquired knowledge. This was typical of the heroic phase of scientific management from the end of the 19th century until the First World War (Accornero, 1980; Zuffo, 2004). Adam Smith (1776) foresaw the importance of the "division of labor" and the causes generating it but he could not see beyond. He could not have known the implications that would follow in terms of productive and cultural assets and daily work. Within the interpretations of industrial work, Taylor's commitment represented a cultural turning point. Taylor outlined a model of management where various disciplines intersected and progressively created a new synthesis.

The industrialization (Hinsley, 1962; Balbo, 1967; Nelson, 1975; Noble, 1977; Jones, 1983; Jacoby, 1984; Schmitz, 1995) required a new theory of interpretation able to handle the new production factors of emerging enterprises, made possible by the significant technical and scientific developments of the era. The relationship between modernity, capitalism, and technology (Geymonat, 1971) became closer, or rather the same as the alliance between modern science and capitalism. This relationship was further strengthened in the name of "techniques," as a paradigm for the modern imaginary rationality consistent with the "bourgeois" mentality (Nacci, 2000). Marx (1857, 1867) clearly foresaw in Das Capital the tendency of the era to substitute the "dead labor" of machinery with living labor of workers. Sombart (1913) spoke of "modern technology," which, unlike previous empirical techniques, was systematically based on science, thus becoming rational. In his view, technological progress was an activity that no longer needed the mediation of man being primarily pursued for its own sake. As Nacci (2000) stated, the contrast between handcrafts and capitalism is perhaps the same contrast that occurred in the transition from ancient techniques to modern technology: that from empiricism to rationalism. At the beginning of the 20th century, Oswald Spengler (1918) spoke of a cyclical progression of science, destined to a great flowering, to reoccur, to wither, and become academic. Taylor's Era was indeed a "Progressive Era," in which scientific and technical knowledge had already been acquired and coupled with increasing available capital. All these factors led to a period of great change, innovation, large capital accumulation and finally to the "decline," as The Decline Of The West stated (Spengler, 1918).

Taylorism as an organic, ideal and incomplete system, collided with the dawn of Ford's moving production line (Russel, 1977), a forerunner element of modern work, which contributed to psychologists revoking their focus on the workers, who were then transformed into dependent variables for technology (Accornero, 1980, 1997).
Twenty years later, Ford faced a fully-developed business system, a relationship with

techniques more engineered and less casual, and an enterprise system at the peak of maturity. Ford gradually reconfigured and circumscribed the idealistic aspects of Taylorism (Benyon, 1973), by hiding them behind an increasing technicality to the point that the power of his original contribution eventually faded and reduced the organization of work into a moving production line (Lee, 1916; Ford, 1922; Nevins, 1954). Therefore Taylorism, considering its idealistic peculiarity, increasingly appears as nothing more than an ideological flag to wave (Wrege & Stotka, 1978; Wrege & Greenwood, 1991; Whitston, 1997); instead of being seen as a subterranean river emerging into daylight, showing us its complexity and legacies for future generations.

Political, Social and Ethical Aspects of Scientific Management

The pursuit of science, his public actions and the personal conduct of the man from Philadelphia stand justified by the social and ethical dimensions inherent in Taylorism (Copley, 1923; Nelson, 1980; Kanigel, 1997). The social value of his theories can be contextualized within the severe economic depression which occurred between 1875 and 1895. A time in which efficiency was becoming a key issue for industry, as it had been generally throughout American society. The 19th century witnessed the advent of globalization represented in its modern form. In terms of scientific and technical development, Germany and England were the most advanced competitors dominating the economic system, while the United States still lacked skilled workers, product knowledge, and know-how. Yet, the United States was becoming the largest market worldwide, consequently having the need for large scale production and process manufacturing (Chandler, 1977). Taylor's work ranked high among this social and economical context. However, only while considering the framework of a still deeply backward industrial reality is it possible to fully understand and value Taylor's actions and practices.

It was indeed the common opinion of the most advanced areas of American East Coast industry that there was a need to pursue rationalization's process and increased competitiveness. This pursuit was inhibited by backward legislation "adventurers" involved in financial fraud and an economic system characterized by insufficient competition and oligopolies (Veblen, 1904). The Efficiency Movement (Angelici, 1928; Forgeaud, 1929; Bonazzi, 1995), culturally influential in Europe, argued that all aspects of the economy, society and government were riddled with waste and inefficiency. Labor force stability, the study and analysis of workers activities and remuneration issues were some of their efforts primarily directed at: outlining new production logic, comprehending machine efficiency, understanding the new setting and function of management and more generally, the problem of resources being wasted.

According to a positivist point of view, Taylor considered social contradictions resolvable through a rigorous and scientific study of production factors. These factors should become the conditions for efficiency, wealth generation and workers' well-being through a full deployment of collective energy and the pursuit of the "good of the nations" (Taylor, 1903, 1911). For Taylor, the selection of workers became a functional need to be verifiable and scientifically proven. Accordingly, Taylor highlighted the weight of the political, social and ethical values produced by science. His books frequently referred to social utility. This clearly appeared in *The Principles of Scientific Management* (Taylor, 1911) and it also emerged from his less political works (Taylor, 1895), and public statements (Taylor, 1912). Great attention to social and ethical issues certainly described Taylor's efforts, but they were also typical of the American scientific community at large (Gantt, 1910) whose main goal was to demonstrate, according to a functional logic, how their theories or models could have collective utilitarian values (Nelson, 1975, 1980; Rossi, 1995). Actually, "the shift from government as an instrument of promotion to a means of regulation was one of the key developments of the progressive spirit" (Gould, 2000, p. 62).

As Taylor (1911, p.1) asserts, "President Roosevelt in his address to the governors at the White House, prophetically remarked that 'The conservation of our national resources is only preliminary to the larger question of national efficiency." Efficiency to obtain through "close, intimate personal cooperation between management and the men," which is the "essence of modern scientific or task management" (Taylor, 1911, p. 10). The reference to Roosevelt in the 'incipit' of *The Principles of Scientific Management* is emblematic of a political choice and an economic conception that considered the common ground between different social factions attained by scientific progress and it's, 'truth'; which represented the essence of scientific management. Similarly, at the end of this work, he referred to the "increase in prosperity and diminution in poverty, not only for the men but for the whole community immediately around the men" (Taylor, 1911, p. 75-76).

The Human Factor

Taylor's most famous works were aimed at obtaining scientific sustainability, while focusing on the needs of the social system, and were also an examination of the 'man at work.' There are many examples of Taylor's attention to the human factor, not only in his books, but also in biographies in which he was the focus, and in the scientific continuity of his *cooperators* (Gilbreth, 1921). Worker selection and evaluation, which led to the further development of applied psychology, is indeed a central aspect of scientific management. There are three famous examples of such, illustrated by Taylor, which represented the first steps between scientific management and applied psychology and also demonstrated their political and ethical justification.

The first example is that of the workman Schmidt who was actually a Dutchman named Henry Noll. This example referred to the controversy over fatigue, which had interested physicians and physiologists from all around the world (Gilbreth & Gilbreth, 1919; Lombardo, Pompili & Mammarella, 2002) since the late 19th century (Mosso, 1891). This argument mainly concerned a social and organizational aspect. Firstly, the value of scientific management may relate to any kind of work organization and to any kind of work, even the simplest, such as pig-iron handling. A second aspect is that of the so called "first class laborer," or rather the man who best personifies the work to be done. The second example is the bicycle 'balls' inspectors selection. It referred to reaction time, which was a standard topic of both applied psychology and of the industrial controversy. Speed and processing times were considered an index of the individual worker's efficiency as well as the performance of a system. The great underlying social issue was that of the eight-hour day, an ongoing controversy within the American industrial association and the labor movement today (Zuffo, 2002).

The third example is the supervisor's evaluation, focusing on which qualities and skills they should have in order to be selected. In *Shop Management* (Taylor, 1903) Taylor recognized the importance of both management evaluation, and the inability of psychology, or rather physiology, to give satisfactory answers (Münsterberg, 1913). Even if the social and political dimensions of management were still limited to an official apparatus such as ASME, Taylor himself led the controversy against a still backward authoritarian and incompetent entrepreneurial system.

Fatigue and First-class Laborer

Taylor's (1911, p. 9) aim was the "substitution of scientific methods for rule-of thumbs methods" thus, within the comprehensive system of Taylor, worker selection assumed a central value. The first step of scientific management was indeed to check the performance of the "techniques" involved, such as machines, shape and choice of tools, measurement and control equipment, but always in relation to the human being. The system required a rigorous analysis of all empirical work processes that were checkable and recognizable in real work situations. Each unique factor of production had to be analyzed, as well as the study of those actions and movements. Features and work rhythms of the workman that were more compatible with other factors in the field, implicated an "*elementaristic logic*" (Gilbreth, 1911; Gilbreth & Gilbreth, 1917, 1919).

Taylor's system found its fulfillment in *Shop Management*, although it is only in *The Principles of Scientific Management* that his system reached its heights, not only theoretically, but also politically and ideologically (as revealed in the case of the workman Schmidt or by that of the bicycle balls' inspectors). This is how Taylor gradually set up his system which primarily involved a method and people able to apply it. Method was considered a link between technologies and human labor, aimed at studying human work and the characteristics (Derickson, 1994) that make up the optimization of performance.

The identification of the "*first-class laborer*" (Taylor, 1911), able to meet the technical and methodological conditions proposed, was indeed one of the most important factors of scientific management. The selection became a prerequisite for the application of the working method and for the achievement of the expected results. The "first-class laborer" concept had a great relevance in Taylor's thinking, despite what happened in the subsequent development of the Fordist mass industry, where the pure rhythm of the moving production line was the only necessary and sufficient condition for human adaptation to the techniques.

When Taylor addressed the problem of reconfiguring the work of the pig-iron handler (Wrege, 2000), taking advantage of the opportunity to study pig-iron loading for the purpose of lowering loading costs, his first step was to "find the proper worker to begin with" through scientific selection (Taylor, 1911). The function of selection was primarily the explanation of required standards, and afterwards, the identification of those men who could be "adapted" to the reference model. The scientific precision with which all factors were analyzed, led to "the possibility of coupling high wages with a low labor cost." This opportunity "rests mainly upon the enormous difference between the amount of work which a first-class man can do under favorable circumstances and the work which is actually done by the average man" (Taylor, 1903, p. 9).

In Taylor's works, the selection procedure followed a double register system. The first level was characterized by an absolute scientific precision based on the academic knowledge of physiology. Like a machine, the human engine can only achieve certain physical results by optimizing fatigue, labor time, and load during the day. In this sense, attention and care for data collection and direct experimentation appeared to be relevant. In order to learn about the developments in Physiology, Taylor sent his assistants to Europe to observe what was only talked about in the American universities (i.e., reaction time), and with his closest *cooperators* he undertook meticulous studies, looking for general laws on issues such as fatigue, physical strength, and use of force. The research had two protagonists: workers of the Bethlehem Steel Company who were controlled and timed while working. "What we hoped ultimately to determine was what fraction of one horse-power a man was able to exert, in essence, how many foot-pounds of work a man could do in a day" (Taylor, 1911, p. 26). Taylor's early hopes were unfulfilled. Even if a large amount of very valuable data on the labor of the two workers had been collected, Taylor and his assistants failed to find any law or constant relationship between work and fatigue. The law, in fact, was found a few years later by Carl G. Barth, one of Taylor's closest *cooperators*, who confined the law "to that class of work in which the limit of a man's capacity is reached because he is tired out" (Taylor, 1911, p. 66).

The second level refers to the organizational behavior and to various personality traits. On this level it was much more difficult for Taylor to find specific information in the literature of that time (Müller & Silberer, 1968). Taylor recognized the lack of appropriate investigation methods, and the consequent importance for selection to "receive the most careful thought and attention" and to "be under the supervision of competent men who will inquire into the experience, and especially the fitness and character of applicants" (Taylor, 1903, p. 61). The importance of this factor can be seen in the fact that in the planning offices, responsible for the study and the continued review of the applications made, there were people involved in this specific task. "We therefore carefully watched and studied these 75 men for three or four days, at the end of which time we had picked out 4 men who appeared to be physically able to handle pig-iron at the rate of 47 tons per day. A careful study was then made of each of these men. We looked up their history as far back as practicable and thorough inquires were made as to the character, habit, and the ambition of each of them" (Taylor, 1911, p. 45).

Schmidt was the name given by Taylor to the selected workman, actually a Dutchman called Henry Noll, who distinguished himself from the others by working on the construction of his own house after a whole day of hard labor. It was also noticed that money had enormous value to him, which suggested that he had the interest and motivation to apply the new method. According to Taylor's words he was one of those men for whom "a penny looks about the size of a cart-wheel" (Taylor, 1911, p. 20). In general, "one of the first requirements for a man who is fit to handle pig-iron as his occupation is that he shall be so stupid and so phlegmatic that he more nearly resembles in his mental make-up the ox than any other type. The man who is mentally alert and intelligent is for this very reason entirely unsuited to what would for him be the grinding monotony of work of this character" (Taylor, 1911, p. 28). Honoring small historical truths, "Noll was more than a muscled brute and exhibited traits not wholly alien to today's middle-class sensibilities" (Kanigel, 1997, p. 317). Alas, though Henry Noll was able to finish the construction of his own home, he lost it years later due to his alcoholism.

In Taylor's pig-tale science, or his pursuit of a scientific model, folk psychology and common sense coexisted. It didn't matter if the pig-iron experiments were little more than common sense observations (Nelson, 1975, 1980) or anecdotal data smoothing out inconsistencies (Wredge & Perroni, 1974; Wrege & Hodgetts, 2000); what really mattered was that Taylor's rigorous method had its own ideological value and determinate direction.

Reaction Time and Workday Duration

Another famous example "in which the 'scientific selection of the workman' counted more than anything else, is well illustrated by the very simple though unusual work of inspecting bicycle balls" (Taylor, 1911, p. 43). In this case the scientific dimension appeared absolutely relevant. This theme has a purely psychological character related to the evaluation of the bicycle balls inspectors and to the study of reaction times. The aim is to select the best inspectors for this kind of job. The experiment is famous and, like everything that appears in *The Principles of Scientific Management* (Taylor, 1911), it is written not only for scientific reasons but also in order to have a political and communicational value. The battle over the working day duration is one of the most important historical factors of the 19th century. In the U.S., there was a severe conflict between the various entrepreneurs, who were in conflict more with each other, than they were with the trade unions that had originated in Chicago in 1886 (Taylor, 1911; Nelson, 1980). Thus, at the beginning of the 20th century, the theme concerned both wages and incentive systems (Taylor 1895; Emerson, 1912; Goldmark, 1912; Bedaux, 1921). In the following years, in proposing tests and other innovations, physiologists (with a word used very often shortly thereafter, *psychotecnics*) often found themselves criticizing Taylor's Scientific Management. Taylor was concerned with the problem of underwork, but also often concentrated and thereby legitimized his attention to overwork.

In the particular case of the bicycle ball inspectors, Taylor showed how the women working at the factory spent a very considerable part of their long workday (10.5 hours a day and 58 hours per week, the legal maximum for women in Massachusetts) in idleness because the required working period was too long. Therefore, Taylor decided to shorten the working hours to ten, but this did not meet with great enthusiasm from the women. A few months later, Taylor shortened the workday to 9.5 hours with two breaks of five minutes each. Then, in September 1897, a month later, he reduced the working day to 8.5 hours. In all these steps the daily pay remained the same, "and with each shortening of the working day the output increased instead of diminishing" (Taylor, 1911, p. 45). Referring to the controversy of his time over fatigue beliefs, Taylor demonstrated how unproductive it was to extend the working time and proposed a rigorous and scientific analysis based on physiological experiments in manual labor.
Physiology (Taylor also uses the term "physiology" to refer to psychological issues) was not only used toward the goal of measuring fatigue in relation to efficiency but

also for selection procedures. By studying the case of the balls' inspectors, Taylor highlighted how attention, as well as fatigue, resulted in a considerable amount of nervous tension, "in spite of the fact that they were comfortably seated and were not physically tired" (Taylor, 1911, p. 45). In particular, the 120 women who had worked in the factory for years required an elevated level of attention. Their job consisted of checking the balls one-by-one, by placing them on the back of their left hand, "in the crease between two of the fingers pressed together, and while they were rolled over and over, they were minutely examined in strong light and with the aid of a magnet held in the right hand, the defective balls were picked out and thrown into special boxes" (Taylor, 1911, p. 44).

Once again empirical and scientific psychology were mixed and merged together. In choosing the best girls to do the job, Taylor and his *cooperator* Sanford Thompson, who was in charge of the reorganization of this department, referred to the academic knowledge of Physiology. At that time in psychological departments, experiments were regularly being conducted "to determine what is known as the 'personal coefficient' of the man tested" (Taylor, 1911, p. 45), or in other words *reaction times* (such as simple and differing kind of compound reaction times). "This test shows conclusively that there is a great difference in the 'personal coefficient' of different men. Some individuals are born with unusually quick powers of perception accompanied by quick responsive action. For others the message is almost instantly transmitted from the eye to the brain, and the brain quickly responds by sending the proper message to the hand. Men of this type are said to have a low 'personal coefficient' while those of slow perception and slow action have a high 'personal coefficient'" (Taylor, 1911, p. 45). The most important quality for a worker was to have a low personal coefficient: "For the ultimate good of the girls as well as the company, however, it became necessary to exclude all girls who lacked a low 'personal coefficient'. And unfortunately, this involved laying off many of the most intelligent, hardest working, and most trustworthy girls merely because they did not possess the quality of quick perception followed by quick action" (Thompson, 1993). Therefore, studies on reaction times have found a great resonance in the history of applied psychology (Boring, 1929; O'Neil, 1968).

The reaction time topic, and consequently the speed at which a job could be done, has been widely considered over the course of decades as absolutely crucial for determining the levels of the wages and piecework. Although in simple language, Taylor already showed the connection with fatigue, stress and the need for work breaks, and in this specific case, managed by the workers themselves.

Selection of the functional foreman

By analyzing "the most important and difficult task" of "selecting and training the various functional foreman who are to lead and instruct the workman," Taylor gives great attention to the aspects of selection and psychological evaluation (Taylor, 1903, p. 72). In particular, Taylor argued that with the introduction of Scientific Management, compared to previous empirical forms of organization, foremen were invested with more burdens and responsibilities (Taylor, 1903; Gilbreth, 1921; Nelson, 1980). Also on this occasion, Taylor illustrated the centrality of psychological factors, while recognizing the lack of scientific knowledge and instruments able to meet scientific management standards. By establishing in advance the difficulty of selecting the functional foremen, Taylor argues that "many of those who appear to have all of the desired qualities, and who talk and appears the best, will turn out utter failures, while on the other hand, some of the most unlikely men rise to the top. The fact is that the more attractive qualities of good manners, education, and even special training and skill, which are more apparent on the surface, count for less in an executive position than the grit, determination and bulldog endurance and tenacity that knows no defeat and comes up smiling to be knocked down over and over again" (Taylor, 1903, p. 72). Perhaps the only selection criteria that Taylor recognizes as "an unquestioned fact" is that "no gang boss is fit to direct his men until after he has learned to promptly obey instructions received from any proper source, whether he likes his instructions or not [...]. The first step is for each man to learn to obey the laws as they exist, and next, if the laws are wrong, to have them reformed in the proper way." Along with honesty and common sense, grit and "constructive imagination" (today this would be called problem solving) represented the foremen's most necessary qualities.

For Taylor, the workmen's features were not determinant in the selection, he looked rather to the correspondence between people and the work to be done. Subsequently, the only way to prove the presence of certain qualities is "through an actual trial at executive work," because success at college, focused on absorption and assimilation, meant little compared to what the individual could express in moral and cultural terms. Besides technical experience, the responsibility for the work and training of other workmen, as well as for command and discipline, was required by the foreman. Therefore, Taylor states: "The difficulty in obtaining in one man the variety of special information and the different mental and moral qualities necessary to perform all of the duties demanded of those men has been clearly summarized in the following list of the nine qualities which go to make up a well rounded man: brains, education, special or technical knowledge; manual dexterity or strength, tact, energy, grit, honesty, judgment or common sense and good health. Plenty of men who possess only three of the above qualities can be hired at any time for laborers wages. Add four of these qualities together and you get a higher priced man. The men combining five of these qualities become hard to find, and those with six, seven, and eight are almost impossible to get" (Taylor, 1903, p. 49). The men's qualities nearly followed the hierarchy existing inside the establishment; from the workman to the manager there had to be a growing technical and "moral" capacity. For Taylor, the need to choose and evaluate people according to their potential was manifest. "If the work is of a routine nature, in which the same operations are likely to be done over and over again, with no great variety, and in which there is no apparent prospect of a radical change being made, perhaps through a term of years, even though the work itself may be complicated in its nature, a man should be selected whose abilities are barely equal to the task. [...] On the other hand, if the work to be done is of great variety, particularly of improvements in methods are to be anticipated throughout the period of active organization the men engaged in systematizing should be too good for their jobs" (Taylor, 1903, p.78).

The development of human resources gained great importance within Taylor's system, according to models that are not dissimilar to what, a few decades later, is still proposed by Scientific Management and Organizational Behavior Schools. "The selection of the men who are employed to fill vacancies or new positions should receive the most careful thought and attention and should be under the supervision of a competent man who will inquire into the experience and particular fitness and character of applicants and keep constantly revised lists of men suitable for the various positions in the shop. […] The knowledge of the character and of the qualities needed for various positions acquired in disciplining the men should be useful in selecting them for employment" (Taylor, 1903, p. 61). The potential of workmen, middle-management and foremen should be evaluated by the same criteria, according to a continuous logic. Tasks and roles should be assigned to workers according to their skills and in anticipation of organizational changes of the specific business area. The task should be in some way challenging, so as to make everyone satisfied with the work assigned and able to fully develop their skills. Facing the occurrence of a disproportion between resources and requirements, Taylor suggested the possibility for the same employer to facilitate the outplacement of *high-flyers* in other production realities able to valorize these resources. This apparent policy of sacrifice is, in contrast, the way to promote the best interest of the establishment. "For one man lost in this way, five will be stimulated to work to the very limit of their abilities, and will rise ultimately to take the place of the man who has gone, and the best class of man will apply for work where these methods prevail" (Taylor, 1903, p. 73). In this way, the best class of man is motivated and encouraged to demonstrate personal initiative and will have the opportunity to rise through the vertical line of command. The functional organization and the centralization of management within the planning department does not inhibit the development of human resources, in fact "the demand for men of originality and brain, capable of performing more brain work and less monotony was never so great" (Taylor, 1903, p. 75).

In addition to theoretical engagement and application engineering, in Taylor there is always an institutional devotion linked to the debate that develops in the industrial and political context of the East Coast on the inefficiencies and backwardness of the industrial system of the time. His thought went beyond the individual company's bounds to assume a dimension more broadly linked to socioeconomic development.

Discussion

Much more than just careful consideration about the professional and technical limits or credits of a scientist have been focused on Taylor's work and personality. His political position aimed at the "good of the nation," linearly expressed throughout his professional practice and theoretical excursus, aptly represented the new needs of a society in rapid transformation. He had a global, not just technical, vision of social development, combining the macroeconomic level of wealth generation (Smith, 1776), competition, consumer and labor with an intermediate level of management and finally with the micro-organizational level of the factory laborer's daily work. Taylorism "defined" the relationship between employer and business systems, between employees' security, and between national interests and wealth valorisation.

Wages and profit were no longer the result of an occasional and spontaneous exchange, or of disturbing power relationships but rather, they became the scientific result of new relations between different social components. Individualism and discord have thus been replaced with cooperation and harmony and mutual distrust with trust (Taylor, 1912). In this climate of cooperation guaranteed by the superiority of science applied to methods and techniques, goods became cheaper and therefore affordable to a wider segment of the population. The focus shifted from the division of surplus to increasing production, making goods that were previously considered a luxury, available to consumers. The largely increased demand implied that "there are more workers than ever before" (Taylor, 1911, p. 71), working to produce a proper offer. For instance, "making shoes at a fraction of their former labor cost" made it possible to sell them "so cheap that now almost every man, woman and child in the working-classes buys one or two pairs of shoes per year and wears shoes all the time" (Taylor, 1911, p. 5).

Harmony between the workmen and their employers was assured by "the whole people, (the consumers), who bought the product of the first two and who ultimately paid both the wages of the workmen and the profit of the employers." The aim of Scientific Management is indeed "the attainment of all three parties through scientific investigation" (Taylor, 1911, p. 73).

Being for or against this specific approach to thinking represented in the following decades, and especially in Europe, a division between different ideological factions and the attempt to favor or oppose a cultural hegemony aimed at social control (Le Chatelier, 1914; Friedmann, 1946, 1950, 1956; Mauro, 1950; Butera, 1972; Braverman, 1974; Coriat, 1979; Accornero, 1997) and political struggle. This match lasted a century. Taylor's Scientific Management had been proposed over the decades as a model and a technically instrumental device, crystallized in its apparently incontrovertible scientific truth. The wager of the attempt to develop resources and create wealth, gradually turned into an effort to maintain power and social control. Taylor was a prophet, regarded both as a source of truth and a symbol of brutal capitalistic oppression; an *ikon* to use for submitting workers to new process technologies through the totalitarianism of rationality, thus enabling the production of the millions of pieces needed for the new international competition of mass industry: explicit and implicit touchstone of the new production logics, as a framework of new work in the 20th century.

Taylorism can also be investigated according to its scientific sustainability. Taylor's whole thinking referred to the traditional paradigm of positivist science. The main pursuit of scientific management was the achievement of scientific rationality and theoretical truth, based on a naive realism, considering data and facts as objective, neutral, and governed by laws to be found in nature. Taylor's thinking was certainly refused in various ways over the decades. His management model was not only the result of an engineering discipline (Emery & Trist, 1965; Woodward, 1965; Bonazzi, 1972), but mainly of a "psycho-sociological conception" of the factory, or a centrality of physiology (Derickson, 1994). However, there was a lack of knowledge induced by the backwardness of the scientific psychology of the time which highlights how business historians had taken no notice of physiologists' indictment towards Taylor's system (Chandler, 1977, 1990; De Masi, 1992; Accornero, 1997). Historians have added to the critique of Scientific Management by calling it unscientific. Daniel Nelson (1975; 1980) stated that "it was little more than [Taylor's assistants'] common sense observation that some ‘rest’ was necessary. Others argued that the most important mistake of Taylor and his associates was simplifying the results of their study and glossing over the inconsistencies, by substituting quantitative analysis with anecdotal data (Wrege & Perroni, 1974).

Beyond the criticisms of several of his contemporaries, and in contrast to his “cooperators” such as Thompson or Frank and Lillien Gilbreth, there was Goldmark (1912) who called for additional research into “the ultimate physical adjustment of the workers to the heightened intensity of their tasks,” and Robert Hoxie (1915) who doubted that time-study practitioners could recognize or eliminate overwork.

Münsterberg, father of applied psychology, was an outspoken supporter of Scientific Management. According to his point of view, Taylor and his “cooperators” first recognized the centrality of the human factor, identifying its correlation with technologies and the opportunity to develop innovative models of work organization. At this level, psychology had a significant role, even if at that time it was not ready to respond to the demands posed by its possible direct applications.

In the United States, industrial research conducted by psychologists and sociologists such as Elton Mayo affected only the surface of Scientific Management and of Taylor’s thinking. In 1916, Elton Mayo started his experiments with a group of colleagues who subsequently became involved in the Hawthorne Studies, among them were F. J. Roethlisberger, Professor of Human Relation, and W.J. Dickson, Chief of the Employee Relations Research Department of the Western Electric Company (Mayo, 1933; Roethlisberger & Dickson, 1939). While agreeing with the general layout of Scientific Management, Mayo did not accept Taylor’s refusal of informal groups as cause for systematic soldering (Taylor, 1911). Mayo’s main belief was in fact that managers must be aware of ‘social needs’ and cater to them to ensure that employees collaborate with the official organization, rather than work against it.

The first internationally significant Psychotechnics Congresses were still confined within the broader developments of Scientific Management and were far from being opposed to Taylor’s model, as testified by the International Congress of Psychology promoted by Claparède in 1920 at Geneva, as well as by the two International Congresses of Psychotechnics held in 1921 in Barcelona and Milan in 1922 (Bauer, 1922; Cerberi, 1923).

In contrast, on the European scene, Taylor’s specific contribution was less recognizable and critiques were stronger and more radical than in the United States. In particular, psychotecnics were set against Taylorism. The same reason given by Taylor to explain the need to introduce Scientific Management (Candeloro, 1919; Mauro, 1927), was used to justify psychotechnics as a “social discipline” in opposition to Taylorism. Scientific issues and ethical justifications were often merged together (Merrick, 1919). Charles S. Mayers (1920, 1922), cofounder of the British Psychological Society and the National Institute of Industrial Psychology and director of the Cambridge Laboratory of Experimental Psychology, highlighted most of the critical aspects of Taylorism. He refused the one best way of Taylorist and Fordist footprints that made the worker crash with the monotony of work and the alienation caused by the impossibility to intervene autonomously in their own work. In France, Lahy’s critiques (Lahy, 1916; Friedmann, 1946) linked to timing practices and overproduction, were already widely available, and the first strikes at the Renault plant related to work organization issues dating back to 1912. In Germany, the dissociation from scientific management was even stronger and aimed at countering the growing oppression of 'chained' work. Giese, von Gottl-Ottienfield and Edgar Atzler preferred psychotechnical and physiological rationalization to Taylorism (Forgeaud, 1929). In particular, Atzler stated that Taylor knew dead machines very well, but ignored the living engine of men, which were the object and aim of psychotechnical studies. Otto Lipmann, influenced by the holistic conception of the individual proposed by Gestalt, opposed elementarism, movements fragmentation, and "the one best way" (Friedmann, 1946).

The first effective theoretical criticism to Taylor's model can be found in Simon's works (1947, 1957) and subsequently in Thompson and Bates (1957)(Cyert & March, 1956; March & Simon, 1958). Basically, Simon called into question the Taylorist model through the "theory of intentional and bounded rationality." In decision-making, Simon believed that managers faced uncertainty about the future and costs in acquiring information in the present. These factors limited the extent to which managers could make a fully rational decision, thus they possessed only "bounded rationality" and must make decisions by "satisfying." Taylor's principle of maximizing efficiency is replaced by the principle of subjective expected utility (Simon, 1957). According to Simon (1957), this was the only rational choice that took into account the cognitive limitations of both knowledge and cognitive capacity, exceeding the psychotechnical dichotomies.

Finally, one last aspect to remember in relation to the European criticism of Taylorism came from Georges Friedmann (Friedmann & Naville, 1961; Friedmann 1946, 1950, 1956). Starting from 1931, he approached the problems posed by work and techniques, contributing to the development of a prestigious French School of Psycho-Sociology that involved several scholars such as Pierre Naville, Alain Touraine and Elliot Jacques, somehow counter-weighing Anglo-Saxon dominance (Harry Braverman, Andrew Friedmann, Richard Edwards, and Michael Burawoy). For these authors, the unequivocal ideological and ethical opposition to Taylorism (we find little difference between Taylorism, Taylor, and Ford) was aimed at the disintegration of the alleged scientific value of the model. Problems of Industrial Mechanization (Friedmann, 1946), while perhaps lacking in rigorous historical value, had abundant testimonial value, was an intensive report of almost every aspect of the psychological effects of industrial work and was also a vigorous indictment of Taylorism. The unscientific nature of Taylorism was not related to historical limitations, such as the unavailability of a usable body of knowledge focused on specific issues (such as fatigue, heavy work and the one best way illusion), but rather to the opportunity to safeguard clearly defined social interests (Friedmann, 1946). Taylor's Scientific Management was thus countered by psychotechnics which would reveal the dehumanization of work through psychological knowledge. Similarly, Harry Braverman (1974) argued that although Taylor was the pioneer of the biggest revolution that ever took place in the division of labor, his work could not be classified as scientific as it had not gone looking for a "better way to work."

For Aris Accornero (1997), an Italian sociologist, the controversy on Taylorism opened a century of "stomach ache," aimed at understanding if and how, ethical and scientific, scientific management actually was. Supporting the hypothesis of the scientific nature of Taylor's model, Accornero (1980, p. 98) says it stands the test of time. "Scientific Management was, alas, a procedure responding to scientific canons. Capitalistic ones? Of course. But, what else? If it was just another form of speed-up, we would not still be here discussing of it. It would not have been a revolution at all. But it shook and reshaped the human work of an entire historical era." Taylorism represented a "crucial turning point that discredited the history of work, dividing the era between two different forms of capitalism and two different types of civilization" (Accornero, 1980, p. 99).

Conclusion

Certainly, Taylor's thinking for his time in comparison to the scientific and social development of other disciplines unknown or little known to him, can be considered to have met the positivist scientific canons. Taylor's specificity can be considered scientific enough for the time in which it was expressed and it obviously assumes "the values and limits of the machine metaphor" (Morgan, 1986).

It will be the specialization of knowledge invoked by Taylor that will eliminate the original coherence and unity supporting his system. Thus, the specialization proposed by scientific management both opens and closes a new era. This apparent paradox belongs to the "Decline of the West" recalled by Spengler, which is also a period during which the positive knowledge achieved its final synthesis, connecting science and ethics, natural sciences and moral values, and nomothetic and idiographic sciences. This particular condition belonged to both functional psychology, that had at last become a science without a soul (such as John B. Watson's behaviorism), and to the fragmentation of management theories, or put another way, endless lines of efficiency or organizational behavior consultants. Scholars, the sons of a new culture induced by mass industry, began to look at fractioned and less holistic knowledge, providing precise answers to specific questions.

Today, we seem to require a reunification of ethics and science. It is therefore useful to recall a passage from Heidegger's Discourse On Thinking: "It is not that the world is becoming entirely technical which is really uncanny. Far more uncanny is our being unprepared for this transformation, our inability to confront meditatively what is really dawning in this age." (Heidegger, 1959, p.85). Our present economic development, induced by technological innovations, cannot always respond to the quality of life improvements of billions of men. Wealth is likely to be distributed less and less. The social fragmentation is growing, and in the meantime, it seems that the financial logics dominating productive factors are becoming independent variables. Certainly, as shown by the subsequent historical events, Taylor's era was not free of problems and questionable phenomena. Soldiers of fortune who accumulate great wealth, difficult legislative struggles for the control of trust and the financial economy and financial fraud of Taylor's time, are all reoccurring problems of our uncertain and sometimes dramatic present day. Taylor's personal battle for distributed wealth with some form of equity and in the light of shared ethics and available sciences, seems thus to be both useful and necessary today.

References

Accornero, A. (1980). *Il lavoro come ideologia.* Bologna: Il Mulino.

Accornero, A. (1997). *Era il secolo del lavoro*. Bologna: Il Mulino.

Angelici, G. (1928). *Il sistema Taylor e l'organizzazione razionale del lavoro.* Roma: Stabilimento tipografico centrale.

Balbo, L. (1967). *A cura di, La classe operaia americana*. Bari: Laterza.

Bauer, J. (1922). Orientamento professionale e Taylorismo. *Atti della III Conferenza Internazionale di psicotecnica applicata all'orientamento professionale*. Milano: Società Umanitaria.

Bedaux, C. E. (1921). The Bedaux – Unit principle of industrial measurement. *Journal of Applied Psychology, 5* (2): 119–126.

Benyon, H. (1973). *Working for Ford*. London: Allen Lane.

Bonazzi, G. (1972). Il taylorismo tra strumento del capitale ed utopia tecnocratica. *Economia & Lavoro, 1*(2).

Bonazzi, G. (1995). *Storia del pensiero organizzativo*. Milano: Franco Angeli.

Boring, E.G. (1929). *A History of the Experimental Psychology.* New York: Century.

Braverman, H. (1974). *Labor and monopoly capital: the degradation of work in the twentieth century*. New York: Monthly Review Press.

Butera, F. (1972). *I frantumi ricomposti: struttura ed ideologia nel declino del taylorismo in America*. Venezia: Marsilio.

Cerberi, G. (1923). *La ricerca delle attitudini nel lavoratore. In Attitudini e orientamento professionale*. Milano: Commissione di studi psicotecnici della Società Umanitaria.

Chandler, A.D., Jr. (1977). *The Visible Hand. The Managerial Revolution in American Business*. Cambridge, MA: Harvard University Press.

Chandler, A.D., Jr. (1990). *Scale and Scope: The Dynamics of Industrial Capitalism. Cambridge*, MA: Belknap Press.

Copley, F.B. (1923). *Frederick W. Taylor, Father of Scientific Management, 2*. New York: Harper.

Coriat, B. (1979). *L'atelier et le chronometer*. Paris: Christian Bourgois.

Cyert, R.M. & March, J.C. (1956). Organizational factors in the theory of oligopoly. *Quaterly Journal of Economics, 70*: 44–64.

De Masi, D. (1992). A cura di, *Processo a Taylor*. Milano: Edizioni Olivares.

Derickson, A. (1994). Physiological science and scientific management in the Progressive Era: Frederic S. Lee and the Committee on Industrial Fatigue. *The Business History Review, 68*: 483–514.

Emerson, H. (1912). *The twelve principles of efficiency*. New York.

Emery, F.E. & Trist, E. (1965). The casual texture of organizational environments. *Human relations*.

Ford, H. (1922). *My life and work*. Garden City, NY: Garden City Publishing Company.

Forgeaud, A. (1929). *La Rationalization: Etats Unis et Allemagne*. Paris: Payot.

Friedmann, G. (1946). *Problèmes humains du machinisme industriel*. Paris: Gallimard.

Friedmann, G. (1950). *Dove va il lavoro umano*. Tr. It. Milano: Edizioni di Comunità, 1955.

Friedmann, G. (1956). *Le travail en miettes.* Paris: Gallimard.

Friedmann, G. & Naville, P. (1961). *Trattato di sociologia del lavoro*. Milano: Edizioni di Comunità, 1963.

Gantt, H.L. (1910). *Work, wages, and profits: their influence on the cost of living*. New York: The Engineering Magazine.

Geymonat, L. (1971). *Linee generali di sviluppo della scienze matematiche e fisico-chimiche nella seconda metà dell'Ottocento. In Geymonat, L. (1971). Storia del pensiero filosofico e scientifico, Dall'Ottocento al Novecento, Vol. V,* Cap. IV, Milano: Garzanti.

Gilbreth, F.B. (1911). *Motion Study*. New York.

Gilbreth, F.B. & Gilbreth, L.M. (1917). *Applied motion study*. New York.

Gilbreth, F.B. & Gilbreth, L.M. (1919). *Fatigue Study*. New York.

Gilbreth, L.M. (1921). *The Psychology of Management*. New York: The MacMillan Company.

Goldmark, J. (1912). *Fatigue and Efficiency: A Study in Industry*. New York.

Gould, L.L. (2000). *America in the Progressive Era, 1890 – 1914*. Harlow: Pearson Education.

Heidegger, M. (1959). *Discourse on Thinking.*

Heidegger, M. (1959). *L'abbandono*. tr. It. Genova: Il Melangolo, 1983.

Hinsley, F.H. (1962). *L' espansione coloniale e i problemi sociali : 1870-1898*, Vol. XI. In Storia del mondo moderno. Cambridge: Cambridge University Press. Milano: Garzanti, 1970.

Hoxie, R.F. (1915). *Scientific Management and Labor*. New York: Appleton & Co.

Jacoby, S. (1984). *The Development of Internal Labor Markets in American Manifacturing Firm*. In Osternam, P (Ed.) Internal Labor Markets. Cambridge, Mass: MIT Press.

Kaneklin, C. (2004). Introduzione. Tra Passato e Presente. In Zuffo, R. G. (2004). Taylor. *Le origini dello Scientific Management e della psicologia del lavoro*. Milano: Raffaello Cortina.

Kanigel, R. (1997). *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*. New York, NY: Penguin Books.

Lahy, J.M. (1916). *Le système Taylor et la psychologie du travail professionnel*. Paris: Masson.

Le Chatelier, H. (1914). *La filosofia del sistema Taylor e altri scritti*, Roma: Enios,1929.

Lee, J.R. (1916). The so–called profit sharing system in the Ford plant. *Annals of the Academy of Political Sciences, vol. LXV*.

Lombardo, G.P., Pompili, A. & Mammarella, V. (2002). *Psicologia del lavoro in Italia.* Milano: Franco Angeli.

Jones, M.A. (1983). *The Limits of Liberty. American History 1607-1980*. Oxford-New York: Oxford University Press. Tr. It. Storia degli Stati Uniti: dalle prime colonie inglesi ai giorni nostri. Milano: Bompiani.

March, J.G. & Simon, H.A. (1958). *Organizations*. New York: John Wiley & Sons.

Marx, K. (1857). *Lineamenti fondamentali della critica dell'economia politica*, Firenze: La nuova Italia, 1968.

Marx, K. (1867). *Il Capitale*. Roma: Editori Riuniti, 1964-66 (3).

Mauro, F. (1927). *Caratteri e finalità dell'OSL*. Roma: Enios.

Mauro, F. (1950). *F.W. Taylor. La vita, le opere, gli epigoni*. Milano: La Cultura Editrice.

Mayers, C.S. (1920). *Mind and work: the psychological factors in industry and commerce.*

London: University of London Press,.

Mayers, C.S. (1922). The Efficiency Engineer and the Industrial Psychologist. In *Atti della III Conferenza Internazionale di psicotecnica applicata all'orientamento professionale*. Milano: Società Umanitaria.

Mayo, E. (1933). *The Human Problems of an Industrial Civilization*. New York: MacMillan.

Merrick, D.V. (1919). *Time Studies as a Basis for Rate Setting*. New York: The Engineering magazine.

Morgan, G. (1986). *Images: le metafore dell'organizzazione*. Milano: Franco Angeli, 1997.

Mosso, A. (1981). *La Fatica*. Milano: Treves.

Münsterberg, H. (1913). *Psychology and industrial efficiency.* London: Constable & Co Limited.

Müller, P. & Silberer, P. (1968). *L'homme in situation industrielle*. Paris: Payot.

Nacci, M. (2000). *Pensare la tecnica. Un secolo di incomprensioni*. Bari: Laterza.

Nelson, D. (1975). *Managers & Workers. Origins of the New Factory System in the U.S. 1880-1920*. Madison: University of Wisconsin Press.

Nelson, D. (1980). *Frederick W. Taylor and the Rise of Scientific Management*. Madison: University of Wisconsin Press.

Nevins, A. (1954). *Ford: the times, the man, the company*. New York: Charles Scribner's.

Noble, D.F. (1977). *America By Design. Science, Technology, and the Rise of Corporate Capitalism*. New York: Knopf.

O'Neil, W.M. (1968). *The Beginnings of Modern Psychology. Harmondsworth*: Penguin.

Roethlisberger, F.J. & Dickson, W.J. (1939). *Management and the Worker*. Cambridge: Harvard University Press.

Rossi, P. (1988). *A cura di, Storia della scienza moderna e contemporanea*. Torino: Utet.

Rossi, P. (1995). *Naufragi senza spettatori. L'idea di progresso*. Bologna: Il Mulino.

Sasso, G. (1984). *Tramonto di un mito*. Bologna: Il Mulino.

Schmitz, C.J. (1995). *The growth of big business in the United States and Western Europe, 1850-1939*. Cambridge, England: Cambridge University Press.

Simon, H.A. (1947). *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. (4th ed. in 1997). Washington, D.C.: The Free Press.

Simon, H.A. (1957). *Models of Men Social e Rational*. New York: Wiley.

Smith, A. (1776). *An Inquiry Into the Nature and Causes of the Wealth of Nations*. Torino: Utet, 1945.

Sombart, W. (1913). *Der Bourgeois*. Munich: Duncker and Humblot, 1913. Translated by M. Epstein as *The Quintessence of Capitalism*. London: Unwin, 1915.

Spengler, O. (1918). Der Untergang Des Abendlandes: Umrisse Einer Morphologie Der Weltgeschichte. München.

Taylor, F.W. (1895). *A piece Rate System. Asme Transactions, 16*: 856-903.

Taylor, F.W. (1903). *Shop Management*. Sioux Falls: Nu Vision Publications-LLC, 2008.

Taylor, F.W. (1906). *On the art of cutting metals*, Trans. Asme, *28* : 31-350.

Taylor, F.W. (1911). *The Prinicples of Scientific Management*. New York: Dover Publications Inc.

Taylor, F.W. (1912). *Deposizione di Taylor davanti alla Commissione speciale della*

Camera dei Deputati. In De Masi, D. (Ed.). A cura di, Processo a Taylor. Milano: Edizioni Olivares.

Thompson, B.C. (1993). *Scientific Management: a Collection of the More Significant Articles Describing the Taylor System of Management*. Harvard University Press.

Thompson, J. & Bates, F. (1957). Technology Organization and Administration. *Administrative Science Quaterly, 2*: 325-343.

Veblen, T. (1904). *La teoria dell'impresa*. Milano: Franco Angeli.

Whitston, K. (1997). The Reception of Scientific Management by British Engineers, 1890-1914. *The Business History Review, 71*(2): 207-229.

Woodward, J. (1965). *Industrial organization: theory and practice*. London: Oxford University Press.

Wrege, C.D. & Greenwood, R.G. (1991). *Frederick W. Taylor. The Father of Scientific Management: Myth and Reality*. Homewood, IL: Business One Irwin.

Wrege, C.D. & Hodgetts, R.M. (2000). Frederick W. Taylor's 1899 pig-iron observations: examining fact, fiction, and lessons for the new millennium. *Academy of Management Journal, 43*(6): 1283-1291.

Wrege, C.D. & Perroni, A.G. (1974). Taylor's pig-tale: A historical analysis of Frederick W. Taylor's pig-iron experiments. *The Academy of Management Journal, 17*(1): 6-27.

Wrege, C.D. & Stotka, A.M. (1978). Cooke creates a classic: The story behind F. W. Taylor's Principles of Scientific Management. *The Academy of Management Review, 3*(4): 736-749.

Zuffo, R. G. (2002). Le origini della selezione professionale. In Il processo di selezione. Un lungo percorso nella storia della psicologia del lavoro. *Il tavolo di Piero, Quaderno Telema, 2*.

Zuffo, R. G. (2004). *Taylor. Le origini dello Scientific Management e della psicologia del lavoro*. Milano: Raffaello Cortina.

The Debate Goes On! A Graphic Portrayal Of The Sinclair-Taylor Editorial Dialogue

Jeremy C. Short
University of Oklahoma

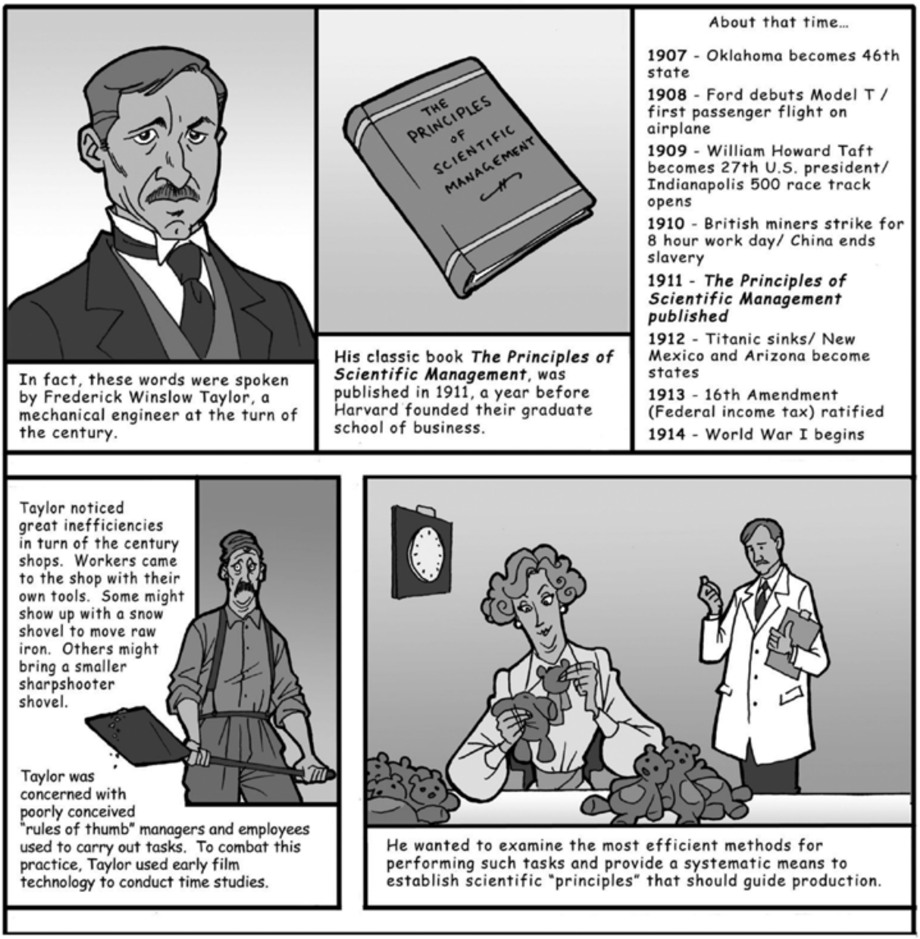
An editorial debate between Frederick Taylor and Upton Sinclair appeared in the American Magazine approximately a century ago. Taylor and Sinclair debated the merits of 'scientific management' versus the exploitation of the workforce as exemplified by Sinclair's highly controversial novel, The Jungle. *This paper provides a 'graphic' retelling of the enduring perspectives espoused by Sinclair and Taylor, and highlights contemporary manifestations of the issues and worries noted by both parties that are prominent in both management practice and organizational scholarship today.*

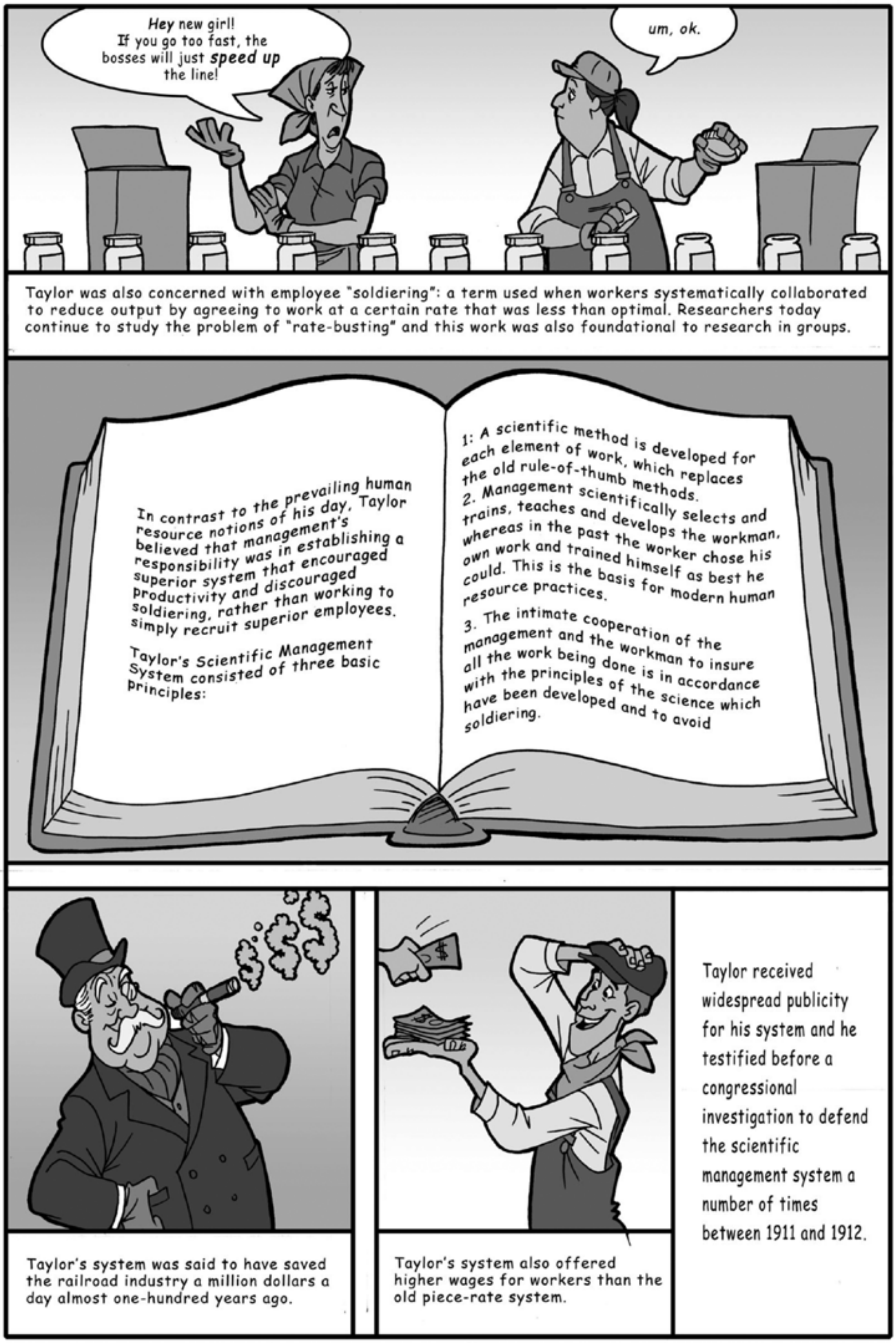
Upton Sinclair's classic book, *The Jungle*, was originally published in 1906. It is known that the book highlighted some of the most abhorrent practices in the meat packing industry found in the United States at the turn of the century. What is also well known is that the popularity of the book and its widespread revelations led to the establishment of the Food and Drug Administration. What is less well known is that Sinclair's primary purpose for writing *The Jungle* was to advocate Socialism as an answer to the troubles found in the tumultuous United States at the turn of the century. Sinclair hoped to convince his readers that Socialism could help right the ills caused by the cold and calculating capitalist machine that seemed to systematically use up, then discard human capital found in the meatpacking plant and related industries highlighted in his book.

A few years after Sinclair's work first appeared, another classic work began to be highly disseminated that would have an equally strong effect on American society and the field of management in particular. That work was Frederick Taylor's *Principles of Scientific Management*, first published in 1911. Taylor's work outlined a rejection of the rules of thumb that guided many business practices and sought for a systematic incorporation of more guided and measurable principles. Taylor's book was the basis of Drucker's concept of management by objectives, and served as the first legitimate 'pop' management book.

In 1911, Frederick Taylor and Upton Sinclair engaged in an editorial debate in *The American Magazine*. The content of this debate had far reaching implications that spur discussion as relevant today as the dialogue between Sinclair and Taylor nearly a century ago. Both Sinclair and Taylor provided graphic depictions of how they saw the world in the early 1900s. To commemorate their debate, I provide a retelling of their debate in graphic novel format, using excerpts from the graphic novel *Atlas Black: Managing to Succeed* (Short, Bauer, Ketchen, & Simon, 2010). I conclude with a brief summary of how their classic works serve as enduring legacies for both men.

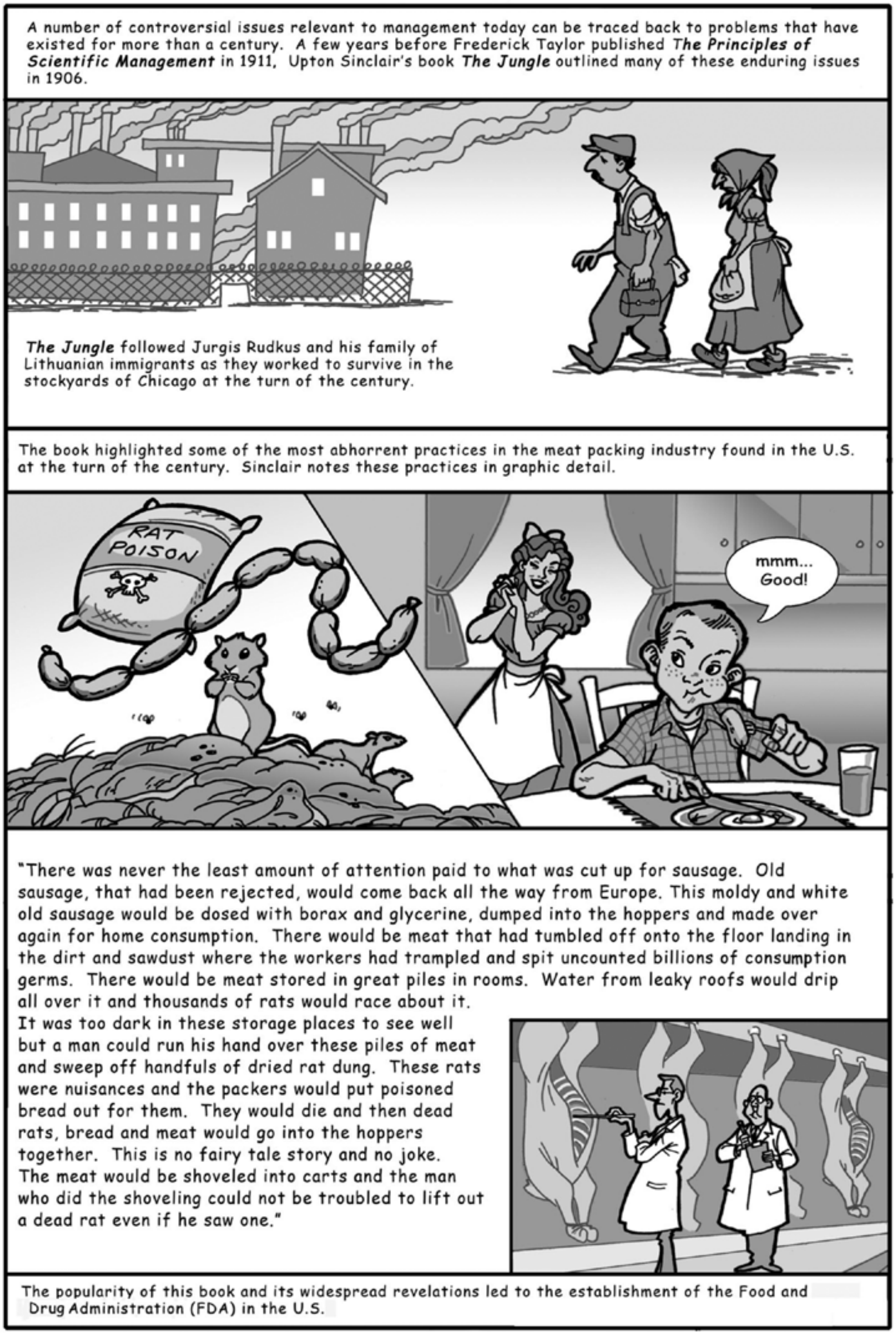

Consider the following quotation:
"We can see our forests vanishing...
Our water-powers going to waste...
Our soil being carried by floods into the sea...
MINE
And the end of our coal and our iron is in sight."
Is this an indictment of a particular political administration? Or perhaps a radical environmental group hell-bent on crippling business and destroying the economy? Ralph Nader, you might guess?


In fact, these words were spoken by Frederick Winslow Taylor, a mechanical engineer at the turn of the century.
THE PRINCIPLES OF SCIENTIFIC MANAGEMENT
His classic book **The Principles of Scientific Management**, was published in 1911, a year before Harvard founded their graduate school of business.
About that time...
1907 - Oklahoma becomes 46th state
1908 - Ford debuts Model T / first passenger flight on airplane
1909 - William Howard Taft becomes 27th U.S. president/ Indianapolis 500 race track opens
1910 - British miners strike for 8 hour work day/ China ends slavery
1911 - ***The Principles of Scientific Management published***
1912 - Titanic sinks/ New Mexico and Arizona become states
1913 - 16th Amendment (Federal income tax) ratified
1914 - World War I begins
Taylor noticed great inefficiencies in turn of the century shops. Workers came to the shop with their own tools. Some might show up with a snow shovel to move raw iron. Others might bring a smaller sharpshooter shovel.
Taylor was concerned with poorly conceived "rules of thumb" managers and employees used to carry out tasks. To combat this practice, Taylor used early film technology to conduct time studies.
He wanted to examine the most efficient methods for performing such tasks and provide a systematic means to establish scientific "principles" that should guide production.


Hey new girl! If you go too fast, the bosses will just speed up the line!
um, ok.
Taylor was also concerned with employee "soldiering": a term used when workers systematically collaborated to reduce output by agreeing to work at a certain rate that was less than optimal. Researchers today continue to study the problem of "rate-busting" and this work was also foundational to research in groups.
In contrast to the prevailing human resource notions of his day, Taylor believed that management's responsibility was in establishing a superior system that encouraged productivity and discouraged soldiering, rather than working to simply recruit superior employees.
Taylor's Scientific Management System consisted of three basic principles:
1: A scientific method is developed for each element of work, which replaces the old rule-of-thumb methods.
2. Management scientifically selects and trains, teaches and develops the workman, whereas in the past the worker chose his own work and trained himself as best he could. This is the basis for modern human resource practices.
3. The intimate cooperation of the management and the workman to insure all the work being done is in accordance with the principles of the science which have been developed and to avoid soldiering.
Taylor's system was said to have saved the railroad industry a million dollars a day almost one-hundred years ago.
Taylor's system also offered higher wages for workers than the old piece-rate system.
Taylor received widespread publicity for his system and he testified before a congressional investigation to defend the scientific management system a number of times between 1911 and 1912.


Taylor applied his system to improve efficiency in a number of arenas. He was an avid sports enthusiast, and Taylor's inventions ranged from aspects of organizational functioning to any operation that would save an individual time.
Taylor won the U.S. Lawn Tennis Association Doubles Championship with the spoon-shaped racket he designed.
He created a shovel designed to handle the optimal load, which he determined was 21 pounds.
He developed a "Y" shaped putter for golf.


Of course, advances brought about with technology are always accompanied by critics. In the same year Taylor published The Principles of Scientific Management, he engaged in an editorial debate with Upton Sinclair whose book, The Jungle, led to the establishment of the Food and Drug Administration.
Sinclair was undeniably the Ralph Nader of his day. He felt that Taylor's methods exploited the worker since they increased efficiency by over 350%, but increased pay by less than 20%.
The Jungle chronicled poor work conditions in turn of the century meatpacking plants.
The Jungle was actually written to promote socialism - and Sinclair may have hoped that the book would promote an outcry to overthrow factories and uplift the common worker. Somewhat ironically, Lenin was a proponent of scientific management and wrote about the need to apply Taylor's system to Russia.
You know, that's why he wrote that song "EIGHT DAYS A WEEK" to get more productivity out of his workers.
That was John Lennon, you dope.
When assessing public response to The Jungle, Sinclair noted, "I aimed at the public's heart, and by accident I hit in the stomach." In the end, capitalism largely won out over the socialistic ideas that were prevalent at the turn of the century, but many challenges evident then remain with us today.


A number of controversial issues relevant to management today can be traced back to problems that have existed for more than a century. A few years before Frederick Taylor published *The Principles of Scientific Management* in 1911, Upton Sinclair's book *The Jungle* outlined many of these enduring issues in 1906.
The Jungle followed Jurgis Rudkus and his family of Lithuanian immigrants as they worked to survive in the stockyards of Chicago at the turn of the century.
The book highlighted some of the most abhorrent practices in the meat packing industry found in the U.S. at the turn of the century. Sinclair notes these practices in graphic detail.
RAT POISON
mmm... Good!
"There was never the least amount of attention paid to what was cut up for sausage. Old sausage, that had been rejected, would come back all the way from Europe. This moldy and white old sausage would be dosed with borax and glycerine, dumped into the hoppers and made over again for home consumption. There would be meat that had tumbled off onto the floor landing in the dirt and sawdust where the workers had trampled and spit uncounted billions of consumption germs. There would be meat stored in great piles in rooms. Water from leaky roofs would drip all over it and thousands of rats would race about it. It was too dark in these storage places to see well but a man could run his hand over these piles of meat and sweep off handfuls of dried rat dung. These rats were nuisances and the packers would put poisoned bread out for them. They would die and then dead rats, bread and meat would go into the hoppers together. This is no fairy tale story and no joke. The meat would be shoveled into carts and the man who did the shoveling could not be troubled to lift out a dead rat even if he saw one."
The popularity of this book and its widespread revelations led to the establishment of the Food and Drug Administration (FDA) in the U.S.

Sinclair's primary purpose for writing ***The Jungle*** was to advocate Socialism as an answer to the troubles found in the tumultuous U.S. at the turn of the century.

Sinclair Writes in ***The Jungle***:

"The Socialists were organized in every civilized nation; it was an international political party...the greatest the world had ever known!"

"The people were tremendously stirred up...but nobody had any remedy to suggest; it was the task of Socialists to teach and organize them and prepare them for the time when they were to seize the huge machine called the Beef Trust and use it to produce food for human beings and not to heap up fortunes for a band of pirates. It was long after midnight when Jurgis lay down upon the floor...and yet itwas an hour before he could get to sleep for the glory of that joyful vision of the people of Packingtown marching in and taking possession of the union stockyards!"

Sinclair hoped to convince his readers that Socialism could help right the ills caused by the cold, calculating capitalist machine that seemed to systematically use up and then discard human capital found in the meatpacking plant and related industries highlighted in his book.


Challenges about tradeoffs between organizational efficiency and how that affects individuals continue to be sources of fear as well as inspiration for workers, managers, entrepreneurs and job seekers. In 1911, Frederick Taylor and Upton Sinclair, two men with very different points of view that have equal lasting effects on the way we see workers, business, and industry engaged in an editorial debate in *The American Magazine*. Taylor and Sinclair each felt strongly that their views would work well for the good of all, but their unique perspectives continue to be at the heart of a debate that continues to this day.
Sinclair was also concerned about drastic job loss because seven out of eight men lost their jobs under Taylor's system.
Sinclair argued that more of the wealth gained through scientific management should be distributed back to society. He suggested that Taylor write a book that would help utilize the full population of the United States rather than one out of eight workers.
Sinclair suggested that if Taylor wrote such a book and then priced it at 50 cents instead of $5, Taylor might sell 2 million copies rather than ten thousand.


Taylor felt that Sinclair unfairly misrepresented the scientific management system.
SALE $$$
He argued that Sinclair only cared about the workman, but society overall did gain in his system due to lower prices. Taylor believed that society actually benefited the most from scientific management.
Taylor also noted that workers did not improve performance based on their own initiative. Improvements were only made because better methods were taught to them by someone else.
Taylor concluded by noting that the most successful societies were the ones where individual workers were the most productive.


In the popular job hunting book, ***What Color is Your Parachute?*** Richard Bolles (2007; PP. 31-32) notes "Every decade creates its own bogeyman to scare job hunters and make them fear for their jobs."
So, tell me about your previous work experience.
ATLAS BLACK RESUME
Oh Boy! How do I turn 3.5 years of waiting tables into relevant management experience?
"One decade it may be illegal immigrants."
"In another, made in Japan."
"In another decade it turns out to be the taking over of manufacturing by robots."
"May I take your order please?"
$$$
"And yet another decade it turns out to be China."
MADE IN CHINA
"Over the last decade It's outsourcing."

Conclusion

A century has now passed since the debate by Sinclair and Taylor. Yet, the concerns and challenges noted by both authors still have a marked, profound, and lasting effect. Their thoughts continue to be a source of fear, as well as an inspiration for future opportunities, for workers, managers, entrepreneurs, and job seekers. Taylor's desire to more efficiently and effectively manage all areas of business production continues to inspire practitioners and scholars in the field of management. Yet, uncertainty about how innovative business practices may displace jobs as well as quality of life continues to provide concern for employees worldwide. Sinclair's perspective that the collective treatment of individuals should be a core value at the societal level still sparks interest in debates involving the interaction of government and business, and such perspectives can be seen in research areas such as social responsibility and social entrepreneurship. His world view also continues to fuel fierce debate, as evidenced in the passionate dialogue leading to recent health care reforms in the U.S. No doubt the ideas of these two great thinkers will continue to be as relevant to management thought in the next century as they have been for the last 100 years.

References

Bolles, R.N. (2007). *What color is your parachute?* Berkeley: Ten Speed Press.

Short, J., Bauer, T., Ketchen., D.J. & Simon, L. (2010). *Atlas Black: Managing to Succeed*. Nyack, NY: FlatWorld Knowledge. ISBN 10: 0-9823618-4-X. ISBN 13: 978-0-9823618-4-9.

Sinclair, U. (1906). *The Jungle*. New York: Dover reprint 2006.

Taylor, F.W. (1911). *The Principles of Scientific Management*. New York: Harper & Brothers.

Citing Taylor: Tracing Taylorism's Technical and Sociotechnical Duality through Latent Semantic Analysis

Nicholas Evangelopoulos
University of North Texas

The body of scholarly works that cite F. W. Taylor's book, The Principles of Scientific Management *is examined. Latent Semantic Analysis, a method that statistically estimates the semantic and conceptual content in textual data, is used to analyze 5,057 titles and 671 abstracts of citing sources. Management concepts and practices, research topics and application contexts, as well as two high-level perspectives of Taylorism are quantitatively extracted as principal components of word usage patterns. The results chart the intellectual territory that was influenced by Taylor's ideas and, through a technical/sociotechnical duality, suggest their continuing relevance through their post-industrial evolution.*

Among many other –isms, the 20th century brought about the advent of Taylorism. Hailed as the triumph of science over traditional management practices by many, denounced as inhuman obsessive technocracy by some, the ideas introduced by Frederick Winslow Taylor (1911) had an undisputable impact on our industrial, organizational, occupational, educational, economic, and sociopolitical world. Soon after publication of *The Principles of Scientific Management* in 1911, Taylor's ideas were received enthusiastically by the business world. Harvard modeled its first MBA curriculum on scientific management, and Taylor was invited by Harvard to lecture annually (Crawford 2009, p. 39). On the occasion of the 100th anniversary of the publishing of *The Principles of Scientific Management*, the work praised by Peter Drucker (1954, p. 280) as the "most powerful as well as the most lasting contribution America has made to Western thought since the Federalist Papers," a reevaluation of Taylor's legacy is in order.

The Principles of Scientific Management and Its Impact on Scholarly Work and Managerial Practice

Efforts in taking stock of Taylor's contribution started soon after his death in 1915. Feiss (1924) credited Taylor with steering management toward a great profession "involving both *science* as applied to the handling of all materials and methods, and *art* as applied to the handling of all its human relations." Locke (1982) examined the validity of Taylor's ideas on time study, standardization, goal setting, money as a motivator, scientific selection, and rest pauses, and finds such ideas fundamentally correct and generally accepted.

The application of Taylor's ideas into management practices was not met without resistance. Health care trade unions argued that "health care cannot be treated like a business" and that "a top-down approach to health care reform will not deliver effective outcomes" (OECD, 2004). Are such reactions justified? Boddewyn (1961) points out that Taylor's polemists often held superficial notions about parts of his system, quoted him out of context, and read or understood his work and his "philosophy of human labor" very little.

Yet, other scholars were not so critical of the contemporary applicability of Taylor's ideas. Investigating whether Taylor's ideas on improving national inefficiency through scientific management are still applicable today, Schachter (2007) found Taylor's spirit still alive in the halls of government and proposed a new look at public sector efficiency that took into account political considerations as intangible costs and benefits and were compatible with the Taylorist approach. Martin (1995, p. 38) found continuity between scientific management and modern TQM and concluded that the fundamental issues of meeting the needs of internal and external customers were fairly similar, therefore Taylor "would be pleased with modern management."

Can the sentiments of partisanship between management and workers be reconciled? In the inaugural issue of the journal *Management Science*, Smiddy and Naum reflected Taylor's idea of "intimate cooperation" between workers and management (Taylor 1911, p. 14; Taylor, 2005, p. 13) by considering the true science of managing to be based upon "a valid, moral, and ethically acceptable philosophy of management by the impartial observation of social components as discrete entities within and related to a total common purpose." (Smiddy & Naum, 1954). So, what happened to the duality of the technical and social component in scientific management as originally intended by Taylor? Were Taylor's ideas misguided by an overestimation of managerial good nature and an underestimation of the possibility for management-labor conflict (Wagner-Tsukamoto, 2008) or is it a misconception of the meaning of "science" resulting in "no such thing as scientific management"? (Carney & Williams, 1997, p. 779). What can be done about scientific management today? Carney and Williams (1997, p. 781) proposed resolving the hard/soft dilemma of classical management which "took Taylor's principles to the extreme" by conflating the distinction between hard and soft sciences, so that "the workplace with its human and non-human content… be understood holistically as an information system."

Such is the discourse on Taylorism, which continues to be strong to this day. But what exactly is the state of affairs in this discourse? What is the sentiment of the community of scholars on Taylor's ideas and their continuing applicability? This paper gauges the context, as well as the manner in which references to Taylor are made. References to Taylor are operationalized as citations that are recorded by a citation indexing database. Context and manner in which scholarly work is presented are operationalized as content in titles and abstracts of the scholarly works citing Taylor. Therefore, the main research questions are:

Research Question 1: What are the contextual and conceptual themes among scholarly sources that cite Taylor?

Research Question 2: How do these themes relate to ideas originally discussed in Taylor's Principles of Scientific Management?

The next section describes the paper's methods of inquiry.

Methods

Data Collection

To gain a comprehensive view of the influence Taylor's ideas had on scholarly activity, two separate studies of citing sources were designed. Combining breadth-first and depth-first search strategies, Study 1 focused on collecting as many scholarly works citing Taylor as possible, while Study 2 focused on collecting those for which an abstract was available. Details of the two studies are provided below. Studies 1 and 2 were complementary and offered two alternative views on the intellectual structure of scholarly work that is influenced by Taylor.

Study 1: In order to gain a broad perspective on scholarly work that is influenced by Taylor, queries on sources that cite publication variants of FW Taylor's *The Principles of Scientific Management* were submitted to the web search engine Google Scholar (http:// scholar.google.com.) Reference variants included the titles *Principles of Scientific Management*, as well as *Scientific Management*. Referenced years included 1911, 1912, 1947, 1948, 1964, 1967, 1971, 1998, and finally 2005, the publication year of 1st World Library's free internet version (available for free download from www.1stworldpublishing.com). In the interest of capturing Taylor's true impact on scholarly activity, all variants were combined. Data cleanup lasted for a few days, but in order to avoid reference inconsistencies, raw data collection was completed on the same day in early July 2010. A total of 5057 journal articles, books, and dissertations were collected, covering the period between 1914 and June 2010. Titles of these citing sources were used as input in the Latent Semantic Analysis step, as described in the next section. Citing source data included 3014 articles published in scholarly journals, proceedings, and periodicals, 1989 books and dissertations, and 54 sources of unknown type. Unlike titles of books or dissertations, article titles occasionally tend to be less self-sufficient; therefore article titles in Study 1 were concatenated with the corresponding periodical names. Examples of the journals represented in this data set include *Academy of Management Review* (42 articles), *Academy of Management Journal* (33 articles), *Public Administration Review* (31 articles), *Management Decision*

(25 articles), *Management* (23 articles), *Human Relations* (22 articles), *Administrative Science Quarterly* (21 articles), and many others, for a total of 1974 journals, conference proceedings, and other scholarly periodicals.

Study 2: In order to gain a deeper understanding of scholarly work that is influenced by Taylor, queries on sources that cite publication variants of F.W. Taylor's *The Principles of Scientific Management* were also submitted to ISI Web of Knowledge (http://isiknowledge.com – subscription may be required), the standard citation indexing service provided by Thomson Reuters. As in Study 1, a number of title variants, as well as publication year variants for Taylor's Principles of Scientific Management were used. As in Study 1, raw data collection was also completed on the same day in early July 2010. A total of 774 journal articles were collected, covering the period between 1994 and June 2010. Since the main point of interest was in collecting abstract data, some articles were excluded, reducing the number of usable articles to 671. The abstracts of these articles were used as input in the Latent Semantic Analysis step, described in the next section. All articles were published in scholarly journals. Examples of the journals include *Public Administration Review* (15 articles), *Academy of Management Review* (13 articles), *International Journal of Operations and Production Management* (11 articles) *Organization Science* (11 articles), and many others, for a total of 369 distinct journals.

Latent Semantic Analysis

Latent Semantic Analysis (LSA) was introduced as an information retrieval technique (Deerwester et al., 1990) but subsequently evolved into a cognitive science theory of meaning (Landauer, 2007). For an introduction to the mathematics of LSA and a small numerical example that illustrates how the analysis works, see Martin and Berry (2007). For a rigorous discussion on how LSA detects the underlying topical structure of a document corpus and why LSA's capability for discovering hidden topics allows it to successfully model synonyms, multiple words with similar meaning, and human memory, see Valle-Lisboa and Mizraji (2007). LSA and the related method Latent Semantic Categorization were used for the identification of key research areas and themes in the body of IS research (Larsen et al., 2008; Sidorova et al., 2008). This article implements LSA by following steps similar to those described in Sidorova et al. (2008), and by following the recommendations in Evangelopoulos, Zhang and Prybutok (2012).

Term frequency matrix. LSA starts with the Vector Space Model (VSM) (Salton, 1975), where a collection of d documents is projected on a set of t dimensions representing dictionary terms. The collection of documents is then quantified as a $t{\times}d$ matrix **X**, containing the number of times each term appears in each document (term frequencies), where columns are documents represented as vectors in a space of terms. Following common practice, some trivial terms such as "the," "of," etc., called *stopwords*, were excluded from the term dictionary. Terms that share a common stem were consolidated (term *stemming*, Porter, 1980). The original raw frequency counts in **X** were transformed by applying the *inverse document frequency* transformation (TF-IDF) which penalizes common terms and promotes rare ones. After being weighted, the term frequencies were also normalized so that the sum of squared transformed frequencies of all term occurrences within each document was equal to one (term *weighting* and *normalization*, Salton & Buckley, 1988). The term dimensionality was further reduced by keeping terms that accounted for 99% (Study 1) or 95% (Study 2) of variability among the top 100 principal components of the term frequency matrix (*communality filtering*, Sidorova et al., 2008). Examples of terms with high communality, that were retained, include *organization*, *management*, *ethics*, *leadership*, *Taylor*, *manufacturing*, *TQM*, etc. Examples of terms with low communality, that were dropped, include *cheap*, *frequency*, *manipulation*, *decomposition*, etc. At the end of all these pre-processing operations, the final term frequency matrix **A** had a dimensionality of 728 terms by 5057 documents in Study 1, and 1634 terms by 671 documents in Study 2.

Singular Value Decomposition. Matrix **A** was subjected to the Singular Value Decomposition (SVD), $\mathbf{A} = \mathbf{U}\mathbf{\Sigma}\mathbf{V}^T$, where **U** are the term eigenvectors, **V** are the document eigenvectors, the superscript ^{T} denotes transposition, $\mathbf{\Sigma}$ is a diagonal matrix of singular values (i.e., square roots of common eigenvalues between terms and documents), $\mathbf{U\Sigma}$ are the term loadings on the common principal components of terms and documents and $\mathbf{V\Sigma}$ are the document loadings on the same common principal components. Full SVD extracted a number of principal components equal to the smallest of the term or document dimensionalities, i.e., 728 principal components (equal to the number of terms) in Study 1, and 671 principal components (equal to the number of documents) in Study 2. Following Zhu and Ghodsi (2006) the profile log-likelihood estimation method was employed in order to detect an "elbow point" on the eigenvalue's scree plot for each study. After applying this method, the first 40 principal components were kept for Study 1, and the first 20 principal components were kept for Study 2. In pursuit of the research questions, in order to explore the semantic content in the two collections at various levels of granularity, a 2-factor solution was also examined for Study 2.

Factor rotations and labeling. Varimax rotations were applied on term loadings and then reciprocated on document loadings. For a more comprehensive discussion on how to find a new base with meaningful dimensions and transform the entire LSA space to the new base, see Hu et al. (2007). In a fashion similar to what is typically done in numerical factor analysis, the rotated term loadings and document loadings were coexamined in order to produce factor labels. For example, in Study 1, the first factor had *organ-*[*ize, ization*] (7.08), *manag-* [*e, ement*] (0.49), and *theori-* (0.47) as the top-loading (stemmed) terms, with numbers in parentheses showing the loadings. Notice that the top-loading term *organ-*[*ize, ization*] has a very high loading, equal to 7.08, while the following terms have loadings that are 0.49 or less. This sharp contrast in loadings continued throughout the 40 factors comprising the solution in Study 1. The top-loading titles for the first factor were "staffing organizations" (0.97), "organization" (0.97), "Sine Ira et Studio – or Do Organizations Have Feelings?" (0.97), "Ethnography in organizations" (0.97), "The management of organizations" (0.84), etc. Notice that the document loadings decreased very slowly, signifying that nearby documents in this rank-ordered list are about equally related to factor 1. A coexamination of top-loading terms and top-loading documents made it clear that the first factor was about the *Organization*. Factor labeling continued in this fashion until the set of 40 labels in Study 1 was completed. In order to validate the labeling process, a confederate was asked to label the 40 factors independently of the author's labeling.

The two sets of labels were practically identical (degree of agreement equal to 100%). The reason the 40 factors in Study 1 were so sharp is perhaps due to the simple nature of the documents (i.e., a cohesive collection of article and book titles). As a result, high contrasts in term loadings made labeling very straightforward in Study 1.

Study 2 required some more involved labeling effort. For example, the first factor in Study 2 had *job-* (0.73), *characterist-* [*ics*] (0.48), *motiv-* [*ate, ation*] (0.46), and *satisfac- [tion]* (0.44) as the top-loading terms. The top-loading document titles were as follows: "Finding workable levers over work motivation" (0.48), "The Work Design Questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work" (0.46), "Integrating motivational, social, and contextual work design features" (0.44), "Predicting employers' satisfaction with newcomers Knowledge, skills, and abilities" (0.36), etc. Please note that in Study 2 only the abstracts were analyzed by LSA. However, a parallel examination of the titles of top-loading articles was expected to be – and actually was – helpful in labeling the factors. After some careful coexamination of terms, titles, and abstracts, it was determined that the first factor is about *Job characteristics*, *satisfactio*n, and *motivation*. The 40-factor solution produced by LSA in Study 1 and the 20-factor and 2-factor solutions produced in Study 2 are presented in more detail in the results section.

Results

Contextual themes

The 40-factor solution in Study 1 (analysis of titles obtained from Google Scholar) offered a view of themes that emerge in the body of scholarly work that drew from Taylor. Factor labels are presented in Table 1, together with some corresponding source counts. The high-loading sources counted in Table 1 were selected based not on a hard threshold (such as the 0.40 loading threshold that is typically used in numerical factor analysis), but, instead, on the heuristic assumption that each document should load, on average, on one factor. This heuristic has also been used in Sidorova et al. (2008). A side-effect of this heuristic was that it offset cross-loading documents (i.e., titles that are strongly related to more than one theme) with an equal number of non-loading documents (i.e., titles that are only weakly related to various themes) which do not contribute to the source count presented in Table 1. Thus, the counts in Table 1 added up to the total number of documents (the discrepancy between 5,057 and 5,058 is only due to rounding error). Table 1 also breaks down the document count into a number of time periods, based on the document (citing source) publication year. Finally, for each factor, Table 1 lists the *variance explained* or *communality* (i.e., the sum of squared loadings of all documents on each factor), expressed as a percentage of *total communality* (i.e., the sum of communalities across all factors). Variance explained is a measure of factor presence in all documents, even those where the factor is only peripherally related, whereas the document count is a measure of a factor's ability to produce fully dedicated documents.

A few selected themes are described below. The descriptions start with each theme's coverage among the citing sources and, in a dialectic fashion, continue by relating back to ideas presented in Taylor's *Principles of Scientific Management*. In the paragraphs that follow, citations to Taylor are made based on page numbers in the 1st World Library's 2005 edition (www.1stworldpublishing.com).

F40.1. Organization. A fundamental socioeconomic business unit, the organization provides the context where management is practiced. Citing sources cover the organization mostly from a theoretical point of view. Taylor (2005, p. 9) adopts a stakeholder view of the organization, stating maximum prosperity of each stakeholder as the "principal object of management."

F40.2. Public administration. Citing sources apply organizational and management theories to the public sector, including the debate on whether government can really run like a business. Taylor (2005, pp. 5-6) relates to public administration from the very first page of his introduction, when he makes a reference to President Theodore Roosevelt's speech on "national efficiency" before laying out the goals of his undertaking.

F40.3. Human resources. Citing sources look at human resources from strategic, social, managerial, as well as developmental viewpoints that also cover ergonomics. Taylor (2005, p. 7) views human resources as a production unit and states the increase of productivity of human effort as one of the main objectives of scientific management.

F40.4. Theory. Theory, the intellectual pursuit of understanding and explanation of various phenomena, is often contrasted with practice. Citing sources look at theory in the context of systems theory, control theory, organizational theories, and often make the distinction between theory and practice. Taylor (2005, p. 26) declares the understanding of "theory, or philosophy, of scientific management" as the main motivation for writing his book.

F40.5. Work. In the context of Study 1, work is treated as a synonym to labor. Citing sources look at work studies, the science of work, and work motivation. Taylor (2005, p. 9) pursues the "highest grade of work" for all workers, through a maximization of their efficiency.

F40.6. Management. Most citing sources refer to the general management of organizations, while fewer look at specific industry contexts (archeological management, lumber mill management, etc.) or specific management functions (strategic management, operations management, etc.). Quite a few citing sources discuss scientific management and, therefore, cross-load on both the management (F40.6) and the science (F40.19) themes. Taylor was fully aware that his work was about management, as evident from the title. His purpose (and, indeed, his accomplishment) was to revolutionize management by making the transition from "personal management" to "systematic management" (Taylor, 2005, pp. 6-7), also arguing that "the best management is a true science" (Taylor, 2005, p. 7).

F40.7. Systems/Information Systems (IS). Information systems as we know them today did not exist in Taylor's time. One source of inspiration for the citing sources was Taylor's (2005, p. 22) dislike of "piece-work systems" which relate to citing sources systems approaches. Another, is the expectation that IS should increase organizational efficiency. Finally, Human-Computer Interaction draws inspiration from Taylor's idea that tool performance should be optimized through a series of scientific experiments. Interestingly, Taylor (2005, p. 35) did call for the "systematic recording and indexing of data" and for a "room in which to keep all the records."

An examination of the remaining themes listed in Table 1 completes the tale of scientific management. A tale of industrial relations (F40.10), industrial psychology (F40.26), employee motivation (F40.22), work (F40.5) and job design (F40.18). A tale of performance (F40.16), task analysis (F40.33), and studies of time (F40.40) and motion. A tale of leadership (F40.13), high-level (F40.20) perspectives (F40.34), innovation (F40.35), and change management (F40.17). The tale of Taylor (F40.32), the man who called for more science (F40.19) in management (F40.6) practices (F40.24). The tale of scientific management, the glorious American way (F40.37) of managing production (F40.36), services (F40.30), human resources (F40.3), processes (F40.29), public administration (F40.2), schools (F40.28), health care (F40.14), information systems (F40.7), and total quality (F40.25).

Table 1: *Contextual themes in citing sources: Study 1, 40-factor solution*

		High-loading source count					
Factor No.	Factor Label	1914-2010 (total)	1914-1970	1971-1990	1991-2000	2001-2010	% Var. explained
F40.1	Organization	185	12	44	52	76	4.19
F40.2	Public Administration	180	4	44	40	91	3.93
F40.3	Human Resources	202	3	35	63	101	3.31
F40.4	Theory	196	13	39	57	83	3.30
F40.5	Work	150	9	38	43	58	3.23
F40.6	Management	85	7	17	24	36	3.21
F40.7	Systems/Information Systems	158	3	28	61	62	3.08
F40.8	Education	162	4	33	52	70	2.94
F40.9	Organizational aspects	123	3	39	26	52	2.80
F40.10	Industrial Relations	128	20	33	31	44	2.79
F40.11	Information Technology	142	1	21	54	65	2.75
F40.12	Social environment	148	5	47	38	55	2.66
F40.13	Leadership	158	6	18	31	99	2.58
F40.14	Health Care	126	0	24	32	69	2.57
F40.15	Development	140	2	31	40	65	2.55
F40.16	Performance	133	3	18	31	79	2.50
F40.17	Change	151	5	25	50	71	2.45
F40.18	Job Design	101	0	27	26	48	2.40
F40.19	Science	158	9	57	41	50	2.39
F40.20	High-level view of Business	130	4	15	37	74	2.36
F40.21	Knowledge	124	0	5	18	95	2.30
F40.22	Organiz. Behavior & Motivation	128	10	57	20	40	2.30
F40.23	Culture	126	0	20	37	66	2.29
F40.24	Practices	131	3	17	42	66	2.28
F40.25	Total Quality Management	96	1	4	53	38	2.27
F40.26	Industrial psychology	125	11	44	28	42	2.26
F40.27	Communication	117	3	25	37	52	2.19
F40.28	Schools	133	2	16	47	67	2.18
F40.29	Processes	115	1	21	39	52	2.12
F40.30	Service	100	1	24	25	49	2.10
F40.31	Learning	121	1	5	34	79	2.09
F40.32	Taylor & History of Sci. Management	94	2	18	22	52	2.07
F40.33	Analysis (of tasks)	115	7	21	30	56	2.06
F40.34	Perspectives	111	2	18	33	57	2.02
F40.35	Innovation	74	2	10	18	43	2.02
F40.36	Production and Operations	99	8	17	30	41	1.98
F40.37	The American way	104	5	31	29	38	1.92
F40.38	Economics	69	2	17	27	21	1.91
F40.39	Administration & Control	35	3	14	6	11	1.85
F40.40	Time	85	6	13	20	46	1.81
	Total	**5058**	**183**	**1030**	**1424**	**2359**	**100**

From themes to contexts and topics

The 20-factor solution in Study 2 (analysis of abstracts obtained from ISI Web of Knowledge) offered a view of contexts and research topics that emerge in the scholarly work that drew from Taylor's principles. Most of the contextual themes extracted in Study 1 were confirmed by Study 2. However, since the documents in Study 2 had a more complex representation, based on abstracts rather than titles, the 20 factors also account for some more complex concepts. Factor labels and a breakdown of high-loading article counts into three time periods, are presented in Table 2. The percentage of variance explained by each factor is also presented in Table 2. The top factor, *job characteristics*, *satisfaction*, *and motivation* (F20.1) accounts for 6.46% of variance explained and has 60 high-loading articles. Knowledge (F20.4) also explains a high percentage of variability (5.62%), but only loads on 34 articles. These statistics indicate that knowledge has a small semantic presence in a large number of articles that cross-load on this factor weakly, in order to produce a combined variance explained of 5.62%, while it also has a substantial semantic presence in a smaller number of articles, namely 34, that load on this factor with a strong loading. In other words, a large number of articles relate to knowledge indirectly, but a smaller number are fully dedicated to knowledge. In contrast, a much larger number of articles, namely 51, are fully dedicated to the topic of *employment* (F20.5), even though the variance explained by employment is smaller than that explained by knowledge, indicating a smaller number of articles that indirectly relate to employment.

Table 2: *Contexts and research topics in citing sources: Study 2, 20-factor solution*

		High-loading article count				
Factor No.	Factor Label	1994-2010 (total)	1994-2000	2001-2005	2006-2010	% Var. explained
F20.1	Job characteristics, satisfaction, motivation	60	18	18	24	6.46
F20.2	Manufacturing & Production	44	16	13	15	5.77
F20.3	Cognitive work	41	15	9	17	5.65
F20.4	Knowledge	34	9	16	9	5.62
F20.5	Employment	51	19	12	20	5.49
F20.6	Human-computer interaction	36	15	14	7	5.08
F20.7	BPR & Innovation	32	15	11	6	5.04
F20.8	Occupational health	25	13	7	5	4.94
F20.9	Time & culture	40	18	14	8	4.92
F20.10	Public administration	32	11	15	6	4.87
F20.11	Nursing	26	13	8	5	4.86
F20.12	Schools	31	13	8	10	4.81
F20.13	Operations mgmt. & service operations	27	9	7	11	4.70
F20.14	Competence	36	14	8	14	4.69
F20.15	Approaches for measurement & evaluation	35	13	13	9	4.67
F20.16	Total Quality Management (TQM)	27	17	6	4	4.66
F20.17	Taylor, Taylorism, & scientific mgmt.	27	11	9	7	4.60
F20.18	Ethics	16	9	4	3	4.52
F20.19	Leadership	20	9	3	8	4.45
F20.20	Education	31	12	11	8	4.20
	Total	**671**	269	206	196	**100**

High-level perspectives in research influenced by Taylor

In order to afford a view of the semantic space created in Study 2 from a vantage point, factor solutions at higher abstraction levels were extracted. A 3-factor solution extracts a systems and *processes* factor, a *physical work* factor, and a *mental work* factor. The three factors produce three corresponding lists of high-loading articles that are of almost equal size. In this paper the 3-factor solution is not pursued any further, as the 2-factor solution is found to be more interesting.

The 2-factor solution produces factors that are labeled as shown in Table 3. The high-loading terms for the first factor (F2.1) include *design, manufacturing, production/product, task, information, performance, improvement, human, quality, technology, process, analysis, measurement, lean*, etc. The high-loading articles for this first factor talk about "quantifiable productivity improvement," "product development," "requirements analysis," "manufacturing organizations," "management of change," "cognitive task analysis," "human factors in engineering," "process improvement," "industrial work design," "knowledge management," etc. This factor is labeled as *technical aspects of engineering & managerial activity* (F2.1).

The high-loading terms for the second factor (F2.2) include *education, public, culture, politics, nursing, school, profession, health, social, administration, care, labor, arguing, economics, ethics, theory, institution, relations*, etc. The high-loading articles for this second factor talk about "trained brains," "bureaucracy in public administration," "cultural cleansing of workplace identity," "discourse in nursing texts," "role changing among educators," "education reforms," "political science," "accountability and the culture of distrust," "school reform," "teacher labor process," "competence in professional practice," etc. This factor is labeled as *social, psychological, & cultural aspects of human activity* (F2.2).

Table 3: *High-level semantic factors in citing sources: Study 2, 2-factor solution*

Factor No.	Factor Label	Article count	% Variance explained
F2.1	Technical aspects of engineering & managerial activity	351	54.77
F2.2	Social, psychological, & cultural aspects of human activity	320	45.23
	Total	**671**	**100**

Relating the lower-level contexts and topics to the higher-level perspectives, Table 4 presents factors from the 20-factor solution extracted in study 2 that cross-load with the two high-level perspectives from the 2-factor solution. In order to further explore the relationship between the 20 contexts and topics and the two high-level perspectives, the observed article counts shown in Table 4 were compared to corresponding expected counts under the independence assumption, obtained through a chi-square test. The 20 topics were then divided into three groups, based on whether they cross-load on factor F2.1 more than expected ("primarily technical aspects of engineering & managerial activity"), on factor F2.2 more than expected ("primarily social, psychological, & cultural aspects of human activity"), or on both factors about equally ("balanced").

Table 4: *Cross-loadings between the 2-factor and 20-factor solutions in Study 2*

	Factor No.	Context or Research Topic	Cross-loading articles F2.1	Cross-loading articles F2.2
Primarily Technical aspects of engineering & managerial activity (F2.1)	F20.3	Cognitive work	41	3
	F20.7	BPR & Innovation	31	4
	F20.2	Manufacturing & Production	42	9
	F20.16	Total Quality Management (TQM)	21	7
	F20.6	Human computer interaction	29	11
	F20.1	Job characteristics, satisfaction, motivation	51	20
	F20.13	Operations mgmt. & service operations	23	11
Primarily social, psychological, & cultural aspects of human activity (F2.2)	F20.18	Ethics	1	14
	F20.12	Schools	6	31
	F20.20	Education	6	28
	F20.17	Taylor, Taylorism, & scientific mgmt.	5	23
	F20.11	Nursing	6	25
	F20.10	Public administration	8	30
	F20.5	Employment	17	45
	F20.19	Leadership	8	15
	F20.8	Occupational health	11	20
	F20.9	Time & culture	16	28
Balanced (both F2.1 and F2.2)	F20.4	Knowledge	25	19
	F20.14	Competence	25	16
	F20.15	Approaches for measurement & evaluation	22	15

Discussion

The analysis of titles in Study 1 offered a comprehensive, yet somewhat superficial view of Taylorist references. Most themes listed in Table 1 are *contexts* for discourse with references to Taylor. Referring to our first research question, these included components of management practice such as the organization, leadership, administration and control, work, production and operations, performance, innovation, change, job design, and time. They also included social and psychological dimensions of management such as industrial relations, industrial psychology, organizational behavior and motivation, the social environment, knowledge, learning, and culture. Finally, they included industries such as public administration, education, health care, information technology, and services. What ideas from the *Principles of Scientific Management* inspired such discourse? Addressing our second research question and making references to Taylor (2005), we can trace these themes to a number of statements and opinions presented in the original text. The concept of *change* (F40.17, see Table 1) is ubiquitous. The entire book was motivated by a desire to bring about change from the old management style to a new, scientific management that could deliver higher levels of efficiency to the industry, higher living standards to the workers, and higher levels of competitiveness to the nations. Taylor's two main illustrations, the pig iron case study (pp. 37-48) and the bicycle balls case study (pp. 79-89) were used with the intent to inspire physical changes through job redesign, as well as changes in attitude (pp. 119-121). *Leaders* (F40.13) must not just be "born right", they must also "be trained" (p. 6), since it ultimately falls upon the managers to "assume the burden of gathering together all of the traditional *knowledge* (F40.21)" (p. 33). The need for education (F40.8) was also pervasive throughout the text. For managers, it is formal college education, with the employment of "a young college graduate", (p. 49) and "college men" (p. 51). For workers, it is organized in-house vocational training, where "expert teachers […] are at all times in the shop, helping and directing the workmen" (p. 113), teaching them "to do a higher class of work" (p. 131). Calling upon management to "take over all work for which they are better fitted than the workmen" (p. 34), Taylor essentially called for a shift in the managers' skill set, and that is a call that has greatly shaped business education in the 20th century and beyond. *Organizational behavior* (F40.22) was also mentioned extensively. From the very beginning of the text, "soldiering," or the worker's deliberate and systematic slow work (p. 13), is cited as a main problem in the individual, industry, and society. Scientific management was then proposed as a method capable of transforming the worker until "he has acquired a friendly mental attitude toward his employers and his whole working conditions" (p. 131). Finally, regarding the applicability of scientific management to a variety of industries, the text focused primarily on manufacturing, but did hint on the generalizability of the ideas presented in it across industries by arguing that "the training of the surgeon has been almost identical in type with the teaching and training which is given to the workmen under scientific management" (p. 115).

The analysis of abstracts in Study 2 allowed for an examination of not just *what* is being discussed, but also *how* scholars articulate their discourse on Taylorism. As Study 2 examined two distinct levels of discourse abstraction, the middle level of contexts and topics, and the higher level of broad perspectives, it also allowed for some higher level findings. Referring to our first research question, at the middle level of semantic aggregation the themes extracted in Study 2 include management concepts and practices such as leadership, competence, knowledge, time and space, business process reengineering (BPR), total quality management (TQM), and Taylorism. They also included topics of scholarly research such as approaches for measurement and evaluation, occupational health, job characteristics, satisfaction, motivation, human-computer interaction (HCI), and cognitive work. Finally, they included industries and application contexts such as operations management & service operations, manufacturing & production, public administration, education, schools, and nursing. Addressing the second research question, it should be noted that many of these themes overlap with the findings from Study 1 and have already been discussed earlier. *Job characteristics* (F20.1) were extensively discussed throughout Taylor's text, which strongly advocates their systematic study through scientific experiments. By pursuing intimate cooperation and harmony between management and the workers, scientific management seeks employee *satisfaction* (F20.1) as "each workman […] is enabled to do a much higher, more interesting […] kind of work" (Taylor 2005, p. 116). The applicability of Taylor's principles on *cognitive work* (F20.3) was illustrated with the bicycle balls case study (pp. 79-89), where "girls" perform inspection of bicycle parts, a work that "required the closest attention and concentration […], [while they were] comfortably seated and […] not physically tired" (p. 80). By envisioning a time when markets are so enlarged that "their men will have almost constant work even in dull times" (p. 131), Taylor expressed his strong interest in issues of *employment* (F20.5). *Business process reengineering* (F20.7) was, of course, not yet invented as a term in 1911, however, the text was full of calls for the introduction of new tools, new processes (pp. 71-78, the bricklaying case study), worker retraining, and a new relationship between management and the workers. Good *occupational health* (F20.8) was and is still a clear goal of scientific management: “in no case is the workman called upon to work at a pace which would be injurious to his health. The task was always so regulated that the man […] will thrive while working at this rate during a long term of years and grow happier and more prosperous” (p. 36). In fact, Taylor went so far as to declare that “If this man is overtired by his work, then the task has been wrongly set and this is as far as possible from the object of scientific management” (p. 125). The study of *time and space* (F20.9) are important components of carrying out task analysis: a college graduate who conducts the experiments is typically recording “with a stop-watch the proper time for all of the motions that were made by the men” (p. 50). *Measurement and evaluation* (F20.15) are main activities performed in the pig iron case study (pp. 37-48), the bricklaying case study (pp. 71-78), as well as the bicycle balls case study (pp. 79-89). Finally, the “vigorous” search for *competence* (F20.14) is presented as a generally acknowledged industry reality. However, “our duty, as well as our opportunity […] [is to] make this competent man, instead of hunting for a man whom someone else has trained” (p. 6). In sum, the answer to the second research question is that the extracted themes, including management concepts and practices, scholarly research topics, and application contexts, corresponded well to the ideas originally discussed in Taylor’s *Principles of Scientific Management*.

At the higher level of semantic aggregation, the ideas articulated by the authors citing Taylor in Study 2 corresponded to traditional technical views of management (work design, task analysis, process design, performance measurement – F2.1), as well as more human-centered, collaborative, socially balanced views (occupational health, industrial psychology, organizational behavior, ethics, public administration, education, health care – F2.2).

After a close look at the high-level factors, an interesting pattern can be noted: factor F2.1 corresponded well with the technical fields of production and operations management, management science, ergonomics, job characteristics, and performance measurement that have primarily *supported* Taylor’s approach, whereas factor F2.2 corresponded well with human-centered, social and psychological views of management that have, to a large extent, antagonized Taylor. A careful examination of articles that load on the second factor reveals that quite a few of them are not much in favor of Taylor. Toman (2003) examined scientific management as an example of “failed technology”. Strangleman & Roberts (1999) found a managerial understanding of culture that can be traced back to Taylor as “dangerously wrong.” Traynor (1996) examined discourse in nursing texts to discover interest in caring, holism, and qualitative research approaches at a time dominated by “so-called market rationalism.” Sinclair, Ironside and Seifert (1996) spoke of “reduced autonomy, deskilling, and work intensification” of teacher labor, stating that the application of Taylorism in the classroom led to “increasingly oppressive working practices.” Yet, not all articles loading on this factor were critical of scientific management. Some treated the scientific approach as positive (Power, 1994), and some others pointed out that too much attention on the negatives of scientific management steers the debate away from more important issues (Reid, 2003).

This paper argues that factor F2.2 was strongly related to discourse on sociotechnical systems as introduced in Trist and Bamforth (1951) and reviewed in Trist (1981), the socio-cognitive engineering approach proposed in Sharples et al. (2002), and the sociotechnical approach to work organization as presented in Prida and Grijalvo (2008). This high-level perspective is, therefore, dubbed as *sociotechnical views*. This is an important aspect of Taylor-based discourse, as it contributed to the evolution of Taylorist ideas in the post-industrial era of the second half of the 20th century. Reflecting the interrelatedness of social and technical aspects of an organization or a society as a whole, sociotechnical theory argues that matching, or "joint optimization" of the two components (technical—plant and machinery, and social—social relations and work organization) is necessary in order to maximize overall system performance (see, e.g., Kelly, 1978 for an overview).

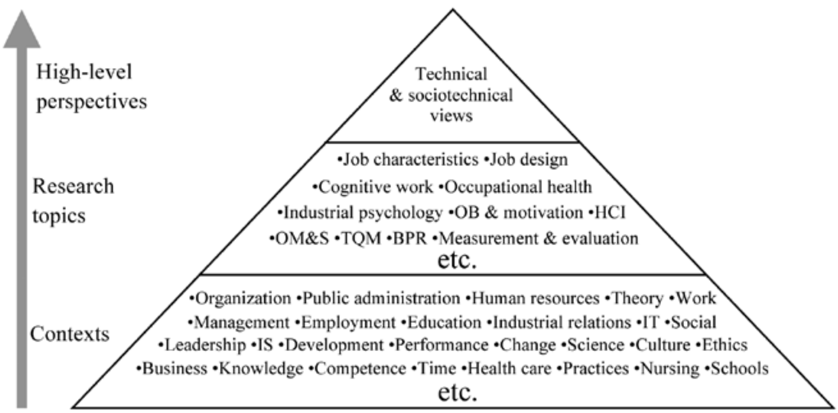
Some sober-minded authors have observed that, even though sociotechnical theory was viewed, at least in the early days, as the antithesis of Taylorism, sociotechnical theory has not discovered any general inapplicability of scientific management (Kelly, 1978), and some others go as far as to propose that the two perspectives can be synthesized (Rousseau, 1977). In fact, Taylor himself presented ideas that were not far from the notion of joint optimization in sociotechnical systems: "intimate cooperation between workers and management" (Taylor, 2005, p. 130) and "almost equal division of the work and the responsibility between the management and the workmen" (p. 34). For Taylor, scientific management provided learning opportunities for workers (p. 6, p. 115) as well as for managers (p. 33), and a desirable future (p. 66) for workers, with involvement in decision-making (p. 117) and promotion prospects (p. 116). Still, the controversy about Taylor's legacy is such that it makes his biographer Robert Kanigel call him the "misunderstood visionary" (Kanigel, 1997, dustjacket). But why is it that Taylor invokes such partisan feelings? Were his ideas hijacked by managers who didn't want to keep their end of the bargain? Are the workers still "soldiering"? Or is it that the two sides simply won't agree to an "intimate cooperation" and keep putting the blame on one another?

Towards the negative side of the discourse on Taylor, authors do not always make an effort to be courteous. Quoting David Lockwood's book *The Blackcoated Worker*, Bain et al. (2002) read "routinized and disciplined work with little chance of promotion" and they instantly recognized Taylor and Scientific Management, even though they admit that neither of the two is mentioned *per se* by Lockwood! What happened to Taylor's idea of enabling each workman to do "a much higher, more interesting, more profitable kind of work"? (Taylor, 2005, p. 116). Scientific management has been reduced to "target setting" and "monitoring" (Bain et al., 2002) and Taylorism becomes a synonym of "deskilling" (Cooper & Taylor, 2000). So much for "intimate cooperation" (Taylor, 2005, p. 25) and "profit sharing" (Taylor, 2005, p. 87) between labor and management being the "essence of scientific management": Taylor said so, but Taylorism didn't!

Comparing the results from Study 1 and Study 2 presented in this paper, one would observe that the extracted factors are complementary and, to some extent, overlapping. Figure 1 synthesized the two studies and summarizes their results at three levels of semantic granularity, visually organized in the form of a pyramid. The themes placed at the lower level of the pyramid represent the contexts in which

Taylor's ideas apply in scholarly work and managerial practice. The research topics placed at the middle level represent processed, more conceptual themes that indicate the scientific lenses through which the contexts placed at the lower level are examined by researchers. These research topics showed how Taylor's ideas continued to evolve in contemporary management research. The two high-level perspectives placed at the top of the pyramid, *technical* and *sociotechnical views*, represent the two main philosophical views in which Taylorism may be examined, and reflect a debate over what Taylorism is, what it is not, and what it ought to be that is still alive today: after all, Taylor may be a real historical figure who went on the record to express his own ideas, but Taylorism is a social construct. Altogether, the pyramid of discourse on Taylorism presented in Figure 1 charts the intellectual territory of practices, ideas, and philosophies inspired by F.W. Taylor, and suggests the continuing relevance of Taylor's original work of 1911 in our time.

Figure 1: *Pyramid of discourse on Taylorism*



Limitations

This paper examined the body of published works that cite Taylor's seminal work, *The Principles of Scientific Management*. In the first study, citing sources data were collected using the internet search engine Google Scholar. Even though the collected sources covered the current scholarly activity that references Taylor fairly well, the limited cataloguing scope of Google Scholar biased the findings. The use of titles as a representation of articles and books also has certain limitations, as titles are not always designed to represent content. As this limitation was addressed in the second study with the introduction of article abstracts collected from ISI Web of Knowledge, citing source coverage was significantly reduced, with collected articles starting with the year 1995. In other words, as depth representation was attempted to be improved upon, coverage breadth and vice-versa were still missing. Still, the noticeable agreement between the results produced by the two studies builds confidence in the main findings.

Conclusion

This paper charted the intellectual territory in the body of scholarly works that cite Taylor. Adopting a bottom-up fashion, it started with the examination of 40 themes extracted from 5,057 article and book titles corresponding to scholarly sources that cite Taylor. These themes, extracted quantitatively as principal components of word usage patterns, primarily correspond to the contexts in which Taylor's ideas have influenced scholarly work and managerial practice. The paper continued with the examination of 20 contexts and topics extracted from 671 article abstracts corresponding to academic research sources that cite Taylor. The latent semantic analysis of Taylor's citing sources concluded by distilling two high-level perspectives that characterize views of management when Taylor was used as a reference: the *technical* and the *sociotechnical* view. Taken together, these two perspectives reflected Taylorism's post-industrial evolution and suggested its continuing relevance into the 21st century. Upon a close look, one cannot help but notice a number of scholarly works, typically aligned with the sociotechnical view, antagonizing Taylor to the point of misquoting him. On the occasion of the 100th anniversary of *The Principles of Scientific Management*, perhaps we should set aside Taylorism for a moment and go back to Taylor. His text is now more accessible than ever.

References

Bain, P., Watson, A., Mulvey, G., Taylor, P. & Gall, G. (2002). Taylorism, targets and the pursuit of quantity and quality by call centre management. *New Technology, Work and Employment, 17*(3): 170-185.

Boddewyn, J. (1961). Frederick Winslow Taylor revisited. *The Journal of the Academy of Management, 4*(2): 100-107.

Carney, D.P. & Williams, R. (1997). No such thing as… scientific management. *Management Decision, 35*(10): 779-784.

Cooper, C. & Taylor, P. (2000). From Taylorism to Ms Taylor: the transformation of the accounting craft. *Accounting, Organizations and Society, 25*: 555-578

Crawford, M. B. (2009). *Shop class as soulcraft: An inquiry into the value of work*. New York: Penguin.

Deerwester, S., Dumais, S., Furnas, G., Landauer, T. & Harshman R. (1990). Indexing by Latent Semantic Analysis. *Journal of the American Society for Information Science, 41*(6): 391-407.

Drucker, P.F. (1954). *The practice of management*. New York: Harper and Brothers.

Evangelopoulos, N., Zhang, X. & Prybutok, V. (2012). Latent semantic analysis: five methodological recommendations. *European Journal of Information Systems, 21*(1): 70-86.

Feiss, R.A. (1924). The life of Frederick W. Taylor: A review. *Harvard Business Review, 3*(1): 85-88.

Hu, X., Cai, Z., Wiemer-Hastings, P., Graesser, A.C. & McNamara, D.S. (2007). Strengths, limitations, and extensions of LSA. In Landauer, T.K., McNamara, D.S., Dennis, S. & Kintsch, W. (Eds.), *Handbook of Latent Semantic Analysis*. Mahwah, NJ:

Lawrence Erlbaum Associates.

Kanigel, R. (1997). *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*. New York: Viking.

Kelly, J. (1978). A Reappraisal of Sociotechnical Systems Theory. *Human Relations, 31*(12): 1069-1099.

Landauer, T.K. (2007). LSA as a theory of meaning. In Landauer, T.K., McNamara, D.S., Dennis, S. & Kintsch, W. (Eds.), *Handbook of Latent Semantic Analysis*. Mahwah, NJ: Lawrence Erlbaum Associates.

Larsen, K.R., Monarchi, D.E., Hovorka, D.S. & Bailey, C.N. (2008). Analyzing unstructured text data: Using latent categorization to identify intellectual communities in information systems. *Decision Support Systems, 45*: 884-896.

Locke E.A. (1982). The ideas of Frederick W. Taylor: An evaluation. *Academy of Management Review, 7*(1): 14-24.

Martin, D. (1995). From mechanical engineering to re-engineering: would Taylor be pleased with modern management? *Journal of Management History, 1*(2): 38-51.

Martin, D. & Berry, M. (2007). Mathematical foundations behind Latent Semantic Analysis. In Landauer, T.K., McNamara, D.S., Dennis, S. & Kintsch, W. (Eds.), *Handbook of Latent Semantic Analysis*. Mahwah, NJ: Lawrence Erlbaum Associates.

OECD (2004). OECD Health Project: Trade Union Advisory Committee (TUAC) statement, meeting of health ministers, 13-14 May 2004. *Organisation for Economic Co-operation and Development, Report* SG/ HEALTH/ MIN(2004)6, 4-May-2004, http://www.oecd.org/ dataoecd/21/31/31644101.pdf [accessed July 31, 2010].

Porter, M. (1980). An algorithm for suffix stripping. Program, 14(3): 130-37. Republished as: Porter, M. (2006). An algorithm for suffix stripping. *Program: Electronic Library and Information Systems, 40*(3): 211-218.

Power, M. (1994). From the science of accounts to the financial accountability of science. *Science in Context, 7*(3): 355-387.

Reid, A. (2003). Understanding teachers' work: is there still a place for labor process theory? *British Journal of Sociology of Education, 24*(5): 559-573.

Rousseau, D. (1977). Technological differences in job characteristics, employee satisfaction, and motivation: A synthesis of job design research and sociotechnical systems theory. *Organizational Behavior and Human Performance, 19*(1): 18-42.

Salton, G. (1975). A Vector Space Model for automatic indexing. *Communications of the ACM, 18*(11): 613-620.

Salton, G. & Buckley, C. (1988). Term-weighting approaches in automatic text retrieval. *Information Processing and Management, 24*: 513-523.

Schachter, H.L. (2007). Does Frederick Taylor's ghost still haunt the halls of government? A look at the concept of governmental efficiency in our time. *Public Administration Review, 67*(5): 800-810.

Sharples, M., Jeffery, N., du Boulay, J.B.H., Teather, D., Teather, B. & du Boulay, G.H. (2002). Socio-cognitive engineering: A methodology for the design of human-centered technology. *European Journal of Operational Research, 136*: 310-323.

Sidorova, A., Evangelopoulos, N., Valacich, J.S. & Ramakrishnan, T. (2008). Uncovering the intellectual core of the Information Systems discipline. *MIS Quarterly, 32*(3): 467-482 & A1-A20.

Sinclair, J., Ironside, M. & Seifert, R. (1996). Classroom struggle? Market oriented education reforms and their impact on the teacher labor process. *Work, Employment & Society, 10*(4): 641-661.

Smiddy, H.F. & Naum, L. (1954). Evolution of a "science of managing" in America. *Management Science, 1*(1): 1-31.

Strangleman, T. & Roberts, I. (1999). Looking through the Window of Opportunity: The Cultural Cleansing of Workplace Identity. *Sociology, 33*: 47-67.

Taylor, F.W. (1911). *The Principles of Scientific Management*. New York and London: Harper & Brothers.

Taylor, F.W. (2005). *The Principles of Scientific Management*. Fairfield, IA: 1st World Library – Literary Society. E-book available for download at http://www.1stworldpublishing.com/ ebooks/e1-4218-0340-2.pdf [accessed October 30, 2011].

Toman, C. (2003). "Trained brains are better than trained muscles": Scientific management and Canadian nurses, 1910-1939. *Nursing History Review, 11*: 89-108.

Traynor, M. (1996). Looking at discourse in a literature review of nursing texts. *Journal of Advanced Nursing, 23*(6): 1155-1161.

Trist, E. (1981). *The Evolution of Socio-Technical Systems: A conceptual framework and an action research program*. Toronto, Ontario: Quality of Working Life Centre.

Trist, E. & Bamforth, K.W. (1951). Some social and psychological consequences of the Longwall method of coal-getting. *Human Relations, 4*: 6-24.

Valle-Lisboa, J.C. & Mizraji, E. (2007). The uncovering of hidden structures by Latent Semantic Analysis. *Information Sciences, 177*(19): 4122-4147.

Warner-Tsukamoto, S. (2008). Scientific management revisited: Did Taylorism fail because of a too positive image of human nature? *Journal of Management History, 14*(4): 348-372.

Zhu, M. & Ghodsi, A. (2006). Automatic dimensionality selection from the scree plot via the use of profile likelihood. *Computational Statistics & Data Analysis, 51*(2): 918-930.

Taylor's Unsung Contribution: Making Interchangeable Parts Practical

John Paxton
Wayne State College

For at least two centuries before they became practical, manufacturers and craftsmen searched for techniques to make identical parts that would exchange quickly and readily between machines of the same type. However, they failed and the solution was not found until the turn of the 20th century. The problem was straightforward, even if its solution was not. This solution is largely unreported in the literature, despite the importance of both the problem and its solution. The idea that the solution came from one of management's giant figures makes this even more difficult to believe, yet it is so.

Frederick Winslow Taylor scarcely needs an introduction. Familiar to any student of management, Taylor is acknowledged as the father of scientific management and the first to bring the scientific method to the study of production and business. His *Principles of Scientific Management* and *The Art of Shop Management* are classics and still available through booksellers, despite being a century old now. Although largely discredited for their (seemingly) narrow focus, they remain as some of the first applications of the scientific method to the art of business, and were largely responsible for the establishment of management as a profession and academic discipline.

Because of this towering reputation, it is often forgotten that Taylor was first educated as a machinist through apprenticeship and later earned a Bachelor's Degree in Mechanical Engineering as a young man. After several other industrial jobs, Taylor came to Bethlehem Steel, where much of his ground-breaking work was done.

This paper is about Taylor's scarcely-acknowledged work relative to part interchangeability and his research that made truly interchangeable parts a practical proposition. The concept of the economical, interchangeable part is the foundational assumption upon which mass production, and thereby modern economies, rests. Without interchangeable parts, there would be no mass production and the quality of modern life would be vastly diminished. Therefore, the very practice of modern management, resting on the accomplishments of Henry Ford (mass production industrial technique) and Alfred Sloan (modern organizational structures and practices, based on high-volume mass production), rests ultimately on the solution to the problems preventing the manufacture of economical interchangeable parts. Frederick Taylor and his team solved these problems.

The literature on "interchangeable parts" stresses the importance of this concept in manufacturing but is strangely silent on the problems; there is simply a vagueness, an ambiguous space in between the failures of Singer and McCormick to move to complete part interchangeability in the late 1880s and 1890s and Ford's move to true part interchangeability with the Model T in 1908. There is an unexplained gap there. This paper will fill in that gap.

Realizing the Need for Parts Interchangeability

The first widely-reported instance of interchangeable parts in Western history was in the mid-fifteenth century, with the advent of Gutenberg's movable type. Actually a segment of a three-part system, movable type contributed markedly to both the Renaissance and the Reformation. Gutenberg's genius was combining the idea of movable type, the use of oil-based ink, and a wooden printing press adapted from olive and fruit presses. In doing so, Gutenberg made printed matter less expensive, just as inexpensive paper was also becoming available. This triggered a surge in literacy as printed material – tracts, pamphlets, and broadsides in addition to books – became more easily and cheaply available. Further, this literacy was not just limited to the upper classes, but was much more widespread throughout the population as well (Burns, 1963). Taylor's work had the same effects on manufacturing that Gutenberg's had on printing – essentially, the creation of a new world culture.

Because of the prevalence of war in Europe between the middle of the 15th century and the end of the 19th century, the arms industry provided the focus for parts interchangeability and mass production during this time frame. Firearms were (1) militarily important, and (2) very expensive - expensive to obtain, expensive to use, and expensive to maintain. It was this confluence of events (military need and scarcity/expense) that made the firearms industry one of the first to launch a concerted search for the "grail of interchangeability." Interchangeable parts would reduce the expense of manufacturing, the expense of use and the expense of repair. As the sizes of the armies increased, this problem became increasingly important.

And this is precisely the problem. Manufacturers had known for some time what needed to be done and also how to do it. It was not replicating identical parts that was the problem. The problem was doing this economically. Parts interchangeability was certainly possible, but it was not the most economical.

The literature on interchangeable parts never states and seldom approaches this critical problem. While the literature talks much about the advantages of parts interchangeability, and the trials of inventors, innovators, and manufacturers in reaching true interchangeability, the closest the literature comes to defining the critical problem is to state that essentially the parts could not be made to fit without hand-filing. Hounshell (1985, p. 23) comes the closest to pinning down the critical technology when he stated:

> The process of hardening parts made interchange impossible because iron always changed its shape during and after this process (parts were worked or machined in a soft state and then hardened for their final use). Even if parts fitted together nicely before hardening, they would not do so after it. They had to be 'restored.' The eminent machine tool builder and master of precision (Joseph Whitworth - this author's note) argued that this could be done 'only by hand labour [sic].'

Simply put, machine-tool cutting edges simply were not hard enough to process previously-hardened steel. The choice then was binary: Leave the steel as "mild steel" in which case it would be too soft to properly perform its function, or "hand fit" the part after hardening (requiring lengthy filing by expert craft masters). In the only reference seen that stated this explicitly, Womack, Jones and Roos (1990, p. 27) stated, "The warping that occurred as machined parts were being hardened had been the bane of previous attempts to standardize parts."

Therefore, the primary problem definition is this: To achieve parts interchangeability, manufacturers need to have the capability to machine parts *after* they have been hardened. Womack et al. (1990, p. 35) further refined this definition: "The key to interchangeable parts . . . lay in designing new tools that could cut hardened metal . . . with absolute precision. But the key to *inexpensive* interchangeable parts would be found in tools that could do this job at high volume with low or no set-up costs between pieces." This latter statement acknowledges the pressure toward incipient mass production at the turn of the century.

This then brings into focus three problems that needed to be solved simultaneously in order to make interchangeable parts a reality. Machine tools had to not only cut hardened steel, but had to do it precisely (Nelson, 1980), and with little setup cost (Smith, 1973). The technology already existed to ensure little setup cost by using "pantograph followers," machine tools which could copy a "master piece" faithfully. For the precision aspect, machine tools just needed a simple redesign to make them heavier and more rigid, a simple fix. But the problem with cutting hardened steel had been, so far, insolvable.

Taylor's Primary Professional Background and Motivations

Brown (2000) cogently argued that Taylor and other mechanical engineers of the time were intimately involved with establishing the engineering profession as the final arbiter of both product design and process design, i.e., the product itself and the processes, materials, sequences, and machining required for its production. Until this time, the engineer "roughed out a sketch" for a product, even those as large as railroad locomotives, then the engineers and the production foremen worked iteratively to make the product. In essence, then, craft production made each product unique. "Men such as William Sellers, Henry Towne, and Frederick Taylor sought this control to aggrandize their own individual power, to achieve autonomy for the engineering profession, and to increase business profits" (Brown, 2000, p. 218). While this may somewhat overstate the case, it is true that, during this time frame, engineering was establishing itself as a profession and was anxious to gain the respect of the manufacturing community.

By employing detailed working drawings, with specifications attached, Brown said, " . . . working drawings represented a substantial managerial incursion into craft workers' autonomy, suggesting a de-skilling motive . . . In particular detailed shop plans shifted two attributes of skill, planning and resourcefulness, out of the workers' control and into the charge of engineers and designers" (Brown, 2000, p. 218).

Further, Brown stated, "The higher cost of skilled labor, arising from the relative scarcity of craft-trained workers in the United States, gave American employers a powerful incentive to routinize tasks " (Brown, 2000, p. 226). Further, "By 1900 or so, collegiate training had become the primary route of entry into American engineering" and "in developing their drafting systems, engineers such as Towne and Frederick Ball were motivated by the control imperative that grew within the professional culture of American mechanical engineering by the 1880s" (Brown, 2000, pp. 228-232). One cannot but help noting that Taylor received his mechanical engineering degree in 1883. Therefore, *control of the shop* and *high efficiency* were part and parcel of the professional lifeblood taught to Taylor in pursuit of his degree.

The Solution

To achieve this control of the shop, Taylor knew that he had to standardize both processes and operations throughput. This meant more precise control of the machines, better planning and standardization of operations, and tighter control of the production process. All of these things though meant eliminating variation within the shop. Until the machines could be made less variable and more precise in operation, shop control was beyond Taylor's (and the profession's) reach.

By the 1890s, then, there were two problems unsolved: the cutting tools and the precision speed control. Taylor solved both of these. Taylor became involved in both the search for better tool steel and in *scientific management* (increasing the reliability and validity of managerial decisions by the use of the scientific method) as a result of his training and education. Brown (2000) makes a strong case for the argument that American engineers were largely focused on control of the production process and control of costs. In his degree program and his shop experience, Taylor was inculcated with these motivations as a professional.

The tool steel used to make cutting tools of the time had been developed in 1868 by Robert Mushet in Scotland. It was a steel alloy containing 2% carbon, 2.5% manganese, and 7% tungsten. However, it dulled quickly when applied to hardened steel and was thus unsatisfactory from both Taylor's perspective and from the perspective of interchangeable parts, which, in order to be uniform enough for interchangeability, had to be machined *after* they were hardened.

In 1894, Taylor began a series of experiments on cutting tools in the Cramp shipbuilding firm (Nelson, 1980). In 1898, he continued his investigation at Bethlehem Steel, still aimed at finding a better cutting-tool-steel-making process from which cutters could be made (Nelson, 1980; Taylor, 1914). The problem with Mushet steel was that cutters made from it heated as they cut and consequently lost both their temper (hardness) and their edge; a steel more tolerant of heat was needed. A new hire, J. Maunsell White III, joined Bethlehem Steel and was assigned to Taylor as an assistant in these experiments. The two complemented each other well and as Neck and

Bedeian, (1996, p. 22) described, "Just eight days after White joined the experiments (23 October 1898), discovery of the high-speed steel techniques, which later produced the Taylor-White patents, occurred." Essentially, these experiments proved that heating the alloys, such as Mushet steel, to a much higher point [300º- 400º F higher (Nelson, 1980); around 1890º F (Neck & Bedeian, 1996)] than previously used, coupled with a liquid-lead bath annealing process, produced a much harder steel (Misa, 1999). In essence, the cutter became harder the faster it cut (i.e., the higher the feed rate was), just the reverse of Mushet steel (Kirby et al., 1996). Kirby et al. (1996, p. 511) went on to say that, "Machine-tool practice was thus revolutionized, and speeds were doubled, tripled, and even quadrupled." Wikipedia (High Speed Steel, p. 1) states, "The Taylor-White process was patented and created a revolution in the machining industries, in fact necessitating whole new, heavier machine tool designs so the new steel could be used to its fullest advantage." In other words, the machine tools themselves became even heavier (i.e., no wooden components) (Smith, 1973; Gordon, 1989) and more rigid), allowing for greater accuracy and greater precision when machining parts (Hounshell, 1985; Gordon, 1989). Further, the new steel allowed cutting previously-hardened parts. This means that parts could be machined after heat-treatment, negating any warping, on machines that performed with greater accuracy and precision. In a contemporary (1900) article in *Railroad Master Mechanic*, an anonymous staff writer reported that a cutter made of Taylor-White steel alloy on a lathe took sixteen minutes at an increased feed rate, used dry (i.e., no cutting lubricant) to form a certain test piece and at the end of this trial, the cutter was unimpaired and still sharp. A cutter of Mushet steel used in the same trial took twenty three seconds to burn out completely (*Railroad Master Mechanic*, 1900). Another contemporary account may be found in *The Metallographist* (1903). More recent accounts may be found in Boothroyd and Knight (1989) and Sheldrake (2003).

Misa (1999, p. 193) presented the following data:

> Under the experimental conditions, tools made of [Mushet] steel could withstand cutting speeds running from 20 to 30 feet per minute. When treated by the new process, these same tools could be run at 60 feet per minute . . . The new cutting power erased the long-standing production bottleneck at the No. 3 ingot lathe. From December 1898 to June 1899, monthly production at the lathe nearly tripled, while the hours of lathe time fell by almost one-third . . . the new steel increased the cutting speed of round-nose tools by 183 percent, their depth of cut by 40 percent, and the pounds of metal they removed per hour by 340 percent.

Further, upon development of the cutting-tool steel, more experimentation by Taylor and his team of subordinates – a mathematician named Knox, Henry Gantt (of "Gantt Chart" fame), and Carl Barth – resulted in the invention and manufacture of slide rules for calculating lathe feed rates and "improved procedures" for setting up and accomplishing lathe work in June of 1899, which increased process reliability and reduced variability (Nelson, 1980, p. 88). In Nelson's words, Taylor and his team:

> ... devised an improved procedure for calculating the appropriate speed, feed, power, and machine times for machine tool operations. By the end of the year he had prepared slide rules for thirteen of the largest lathes in Machine Shop No. 2. Taylor was ecstatic. At last he had a way to determine proper machine tool methods. Control of the metal-cutting machinery, the most elusive element in the machine shop environment, was within his grasp (Nelson, 1980, p. 88).

Between vastly improved shop drawings that included tolerance specifications (i.e., modern drafting practices) and the improvement of process practices noted above, shop control and cost reduction was well within the reach of practicing mechanical engineers, thanks to Taylor and White.

However, this accomplishment was neither fast nor easy. Misa (1999) clearly documents experiments beginning in 1881 and stretching to 1898, in four separate companies. In 1898 at Bethlehem alone, the critical experiments took 16,000 iterations, consumed eight to nine months, and cost (estimated) between $50,000 and $125,000 at Bethlehem Steel. From a scientific perspective, the reason for so many experiments was failure to gain positive results and failure to assure replication. The perfection of the Taylor-White high-speed cutting steel took immense dedication, faith, and will.

Taylor was, at the same time, active in mechanical engineering circles (e.g., President of the American Society of Mechanical Engineers (ASME), 1906-1907), publicizing the Taylor-White process. Taylor and White were awarded the Elliott Cresson Medal by the Franklin Institute in 1902. Taylor was given an award for the same accomplishment at the Exposition Universelle Internationale in Paris in 1900 (Neck & Bedeian, 1996). All of these helped increase the visibility of the Taylor-White process, and spread the word about the new "high-speed cutting steel."

The first of the keys to interchangeable parts was present at last. The second and final part quickly followed. At this time (circa 1900), machine tools were driven by a central power source, usually a steam engine. The steam engine turned a large, central drive line, equipped at regular intervals with large pulleys. These pulleys were in turn connected to the machine tools by a wide leather or canvas belt. This system is known as a "line-shaft, belt-drive" system. Biggs (1996, p. 84) showed a particularly interesting photo of such a machine shop in her work. Devine (1983, p. 352) described speed control on such a system: " To run any particular machine, the operator activated a clutch or shifted the belt from an idler pulley to a drive pulley using a lever attached to the countershaft. Multiple pulleys offered speed and power changes."

Obviously, such a system was variable only in discrete increments, as one changed from a larger to a smaller pulley or vice versa. Intermediate speeds were impossible, except by the addition of more pulleys. Such a system negated some of the advantages of Taylor's research on optimum speed and feed rates. In addition, the belts, made of canvas or leather, tended to stretch and wear over time, making speed control even less reliable. Taylor was one of the first, if not the first, to equip an experimental lathe with an electric-motor drive (Misa, 1999), making him a pioneer of what is now common practice through the machine-shop world; "unit drive" and precision speed control via electric motor. Precision speed control was easily achieved on these motors by known technology (e.g., variable resistors or potentiometers) (Devine 1983). Thus was the second major consideration solved.

By 1901, both the cutting tool and precision machining problems were solved, both solutions courtesy of Frederick Winslow Taylor and his subordinates. Taylor had solved the major problems preventing the manufacture of interchangeable parts and thus dissolved the stumbling block holding back mass production. Arguably, this is the most significant of Taylor's many notable accomplishments.

The Effects: Short-Tterm

The effect of Taylor-White tool steel in essence established the practicability of interchangeable parts. For the first time, steel parts could be hardened and then machined precisely, preventing the warping that had, for decades, delayed the realization of machine-made, precision interchangeable parts. For the first time, the reality of ". . . inexpensive interchangeable parts would be found in tools that could do this job at high volume with low or no set-up costs between pieces" could be realized (Womack, Jones & Roos, 1990, p. 35).

In addition, and in tandem with the new cutting tool experimentation, the additional research guided by Taylor, on optimum feed and cutting rates did two things: (1) it showed that scientific calculations for particular machines were possible and desirable, and (2) it showed dramatically the effects of making and using such calculations. Hounshell (1985, p. 232) commented,

> In Chapter 2 [sic] the question was raised of whether in the 1870s and 1880s high-volume, economical production of accurate parts was technologically possible. By 1913, when Colvin wrote the series in the *American Machinist* and when Ford initiated line assembly techniques, the machine tool industry was capable - perhaps for the first time - of manufacturing machines that could turn out large amounts of consistently accurate work.

In other words, the work of Taylor and White concerned with producing high-speed tool steel capable of machining hardened steel parts was critical to the production of interchangeable parts; it was the key which had been missing for some 200 years.

Longer-range effects and conclusion

Interchangeable parts were key to the evolution of high-volume mass production (HVMP). Hounshell (1985) relates these advances as directly applied to Ford's Model T design, plant layout, and production.

Table 1: *Total automobile production at Ford by year*

1903=1700	1904=1695	1905=1599	1906=2798
1907=6775	1908=6015	1909= 10660	1910=18942
1911=34610	1912=66640		

The total climbed rapidly after that as the Model T production, started in 1908, took hold and the production system evolved (Gunnell, 2002, pp. 20-28).

It is obvious that something revolutionary began happening at Ford between 1906 and 1912. The production totals show traditional "craftsman" manufacture between 1903 and 1906. But in 1907 and beyond, the production totals show the beginning of an exponential rise. Something significant had happened. That "something significant" here was the Model T. Design of the Model T began in 1906, and the design was predicated on interchangeable parts and ease of economical manufacture. Without the contribution of Taylor and White (the mechanical engineers, not the managers), neither of these would have been possible.

The success of the Model T – and the underlying development of modern industrial technique triggered by Taylor-White high-speed cutting steel tools – catalyzed the entire automobile industry. In response to Ford's commanding position in the auto industry, Alfred Sloan began redesigning General Motors and the Chevrolet Division in particular to compete with Ford Motors. This redesign, taking until 1928, was the birth of the modern corporation (Paxton, 2009). Included were modern cost accounting, strategic planning, marketing, finance, and organizational structure. Both the industrial techniques and the corporate structure – the bedrock foundations of modern management – survive today and both were directly triggered by Taylor, White, and their experiments which resulted in high-speed cutting tool steel.

By 1928, HVMP (high-volume mass production) and the modern corporation had reached maturity (Paxton, 2009); both were realities throughout the United States. These essentially rebuilt the culture and society of the nation (Gordon, 2004). Both Taylor and White died prior to 1916, White in 1912 (Neck & Bedeian, 1996) and Taylor in 1915 (NY Times obituary). But by scientifically pursuing the research that invented high-speed cutting tool steel, thereby making interchangeable parts possible, both Taylor and White contributed greatly to the Allied victories in both World War I and World War II, for in both of these wars, the United States was the only national economy based on a mature system of high-volume manufacture (World War I) and that had the only mature high-volume mass production economy in the world (World War II) (Paxton, 2009). Beyond this, their technology proved instrumental in improving the quality of life across the globe in the second half of the 20th century. Quite a contribution, unsung and largely unrecognized as it is.

References

The Metallographist.Volume 6, Number 2: 130 (April, 1903), p.130. Accessed at http://books.google.com/books?id=1voCAAAAYAAJ&pg=PA130&lpg=PA130&dq=the+metallographist+and+the+taylorwhite+process&source=bl&ots=6Acb46iId7&sig=oD4Bzx0NORa94buysmBP6xvbFgc&hl=en&ei=NWBsS6vbEZT4sQOepOWxDQ&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAcQ6AEwAA#v=onepage&q=&f=false on February 5, 2010.

Obituary: F. W. Taylor. *New York Times*, March 22, 1915. Retrieved from http://www.nytimes.com/learning/general/onthisday/bday/0320.html on February 5, 2010.

Railroad Master Mechanic, Volume 24: 527. (1900), p.527. Accessed at http://

books.google.com/books?id=YSU2AAAAIAAJ&pg=PA527&lpg=PA527&dq=Railroad+Master+Mechanic,+1900+and+the+taylor-white+source=bl&ots=W0o7FtQz6A&sig=LVi4KAF_7QEsFLn7F0g58XCMCGA&hl=en&ei=7WFsS_mpBor-tAP21OWyDQ&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAcQ6AEwAA#v=onepage&q=&f=false, February 5, 2010.

Biggs, L. (1996). *The Rational Factory: architecture, technology and work in America's age of mass production*. Baltimore, MD: The Johns Hopkins University Press.

Boothroyd, G. & Knight, W. A. (1989). *Fundamentals of Machining and Machine Tools*. New York: McGraw-Hill, Inc.

Brown, J. K (2000). Design plans, working drawings, national styles: engineering practice in Great Britain and the United States. *Technology and Culture, 41*(2).

Burns, E.M. (1963). *Western Civilizations: their history and culture* (6th ed). New York, NY: W. W. Norton and Company.

Devine, W.D. Jr (1983). From shafts to wires: historical perspective on electrification. *The Journal of Economic History, 43* (2): 347-372.

Gordon, J.S. (2004). An empire of wealth: the epic history of American economic power. New York, NY: Harper Perennial.

Gordon, R.B. (1989). Simeon North, John Hall, and Mechanized Manufacturing. *Technology and Culture, 30* (1): 179-188.

Gunnell, J. (2002). *Standard Catalog of Ford, 1903-2003* (3rd ed). Iola, WI: Krause Publications.

High Speed Steel. (n.d.) http://en.wikipedia.org/wiki/

Hounshell, D.A. (1985). *From the American System of Mass Production, 1800-1932*. Baltimore, MD: The Johns Hopkins University Press.

Kirby, R. S., Withington, A. B., Darling, A. B. & Kilgour, F. G. (1956). *Engineering in History*: 511. New York, NY: McGraw-Hill, Inc.

Misa, T.J. (1999). *A Nation of Steel: the Making of Modern America, 1865-1925*. Baltimore, MD: the Johns Hopkins University Press.

Neck, C.P. &. Bedeian, A.G. (1996). Frederick W. Taylor, J. Maunsell White III, and the Matthew Effect: the rest of the story. *Journal of Management History, 2* (2): 20-25.

Nelson, D. (1980). *Frederick W. Taylor and the Rise of Scientific Management*. Madison, WI: The University of Wisconsin Press.

Paxton, J. (2009). Engineering, management, and economics: a case study in alloying disparate elements. *International Journal of Continuing Engineering Education and Life-Long Learning, 19* (1): 82-96.

Sheldrake, J. (2003). *Management Theory.* London: Thomson.

Smith, M.R. (1973). John H. Hall, Simeoon North, and the Milling Machine: the nature of innovation among antebellum arms makers. *Technology and Culture, 14* (4): 573-591.

Taylor, F.W. (1914). *The Principles of Scientific Management.* New York, NY: Harper and Brothers Publishers.

Womack, J.P., Jones, D.T. & Roos, D. (1990). *The Machine that Changed the World: The story of lean production*. New York, NY: HarperPerennial.

Scientific Entrepreneurial Management: Bricolage, Bootstrapping, and the Quest for Efficiencies

Manjula S. Salimath
University of North Texas

Raymond J. Jones III
University of North Texas

Frederick Taylor is well recognized for his principles of scientific management. Scientific management was designed with the intent of seeking greater efficiencies in the use of labor and the consequent production of material goods. More notably, scientific management was tested and promoted primarily in the context of established and larger businesses. We argue that Taylor's quest for efficiencies can apply in yet another context, that of entrepreneurial firms and small businesses. Bricolage and bootstrapping are presented as two resource management techniques used by entrepreneurs that closely resemble Taylorian efficiency perspectives. Taylor's relevance to the scientific management of entrepreneurship is discussed.

Since its publication a century ago, Taylor's classic treatise on the principles of scientific management (Taylor, 1911) has been instrumental in revolutionizing management thought. Taylor was primarily motivated by the need for greater national efficiency, and responded to President Roosevelt's call of the hour to conserve national resources as the first step on the road to reaching national efficiency. Taylor recognized that the greatest wastage of resources occurred in the area of human effort, as they were "less visible, less tangible, and are but vaguely appreciated" (Taylor, 1911, p.5). Towards this end, he systematically dedicated his efforts to improve, via scientific methods, the efficient and non-wasteful usage of human, material, time, technological, and capital resources.

Scientific management can therefore be viewed under the broader framework of resource management techniques or approaches that are applicable to businesses. The management of resources is of critical importance because strategic management scholars have found that the mere possession of resources by itself is unlikely to lead to a long term competitive advantage or superior performance. Hence, strategic management (Teece et al., 1997) and resource based views (Barney, 1991) suggest that adequate resources are probably necessary but insufficient to ensure a firm's competitive advantage. Exploiting resources in unique and inimitable ways creates avenues for superior productivity. Creating value through resource combining and developing dynamic capability is essential for a sustainable competitive advantage (Teece et al., 1997; Eisenhardt & Martin, 2000). Dynamic capabilities allow firms to alter their resource base (Helfat, 1997) by extending, modifying or creating resources. The principal objective of scientific management was to ensure the maximum prosperity for both the employer and the employee. This maximum prosperity, according to Taylor, undeniably occurred when the individual reached the highest state of efficiency. As such, "maximum prosperity can exist only as a result of maximum productivity" (Taylor, 1911, p.12). In line with the logic of dynamic capabilities, Taylor emphasized the economical usage and combination of human and material resources to provide a higher level of productivity and performance. From this perspective, scientific management was an early precursor to the notion of dynamic capabilities and resource-based views of the firm.

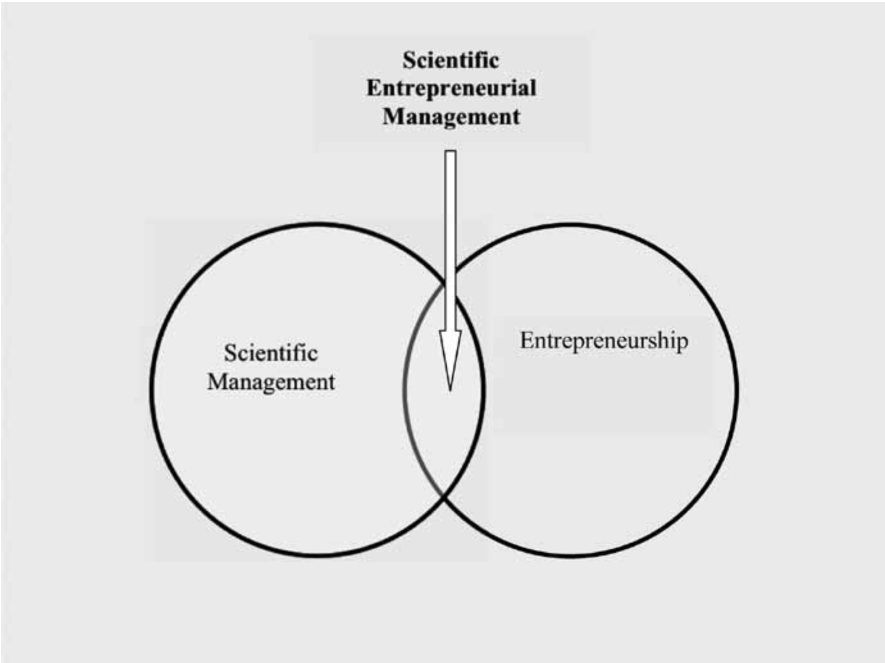
In this paper, we therefore view scientific management as a subset of the firm level resource management approaches that are available to businesses. No doubt, scientific management involves much more than resource management techniques or systematic experimentation. Therefore, it must be noted that we do not utilize all the principles of scientific management, but only some of them, as relevant to our objective. The rest of the paper (in which the primary objective is to showcase the relevance of Taylor's work to entrepreneurial practice) is organized as follows. First, we uncover the similarities in objectives between entrepreneurship and scientific management's mutual quest for efficiencies. Next, we present bricolage (i.e., improvisation) and bootstrapping (i.e., operating effectively without external/financial help) as particular examples of entrepreneurial behavior that reflect Taylor's principles of scientific management. Finally, we conclude with implications and the relevance of Taylor's work to enhance our understanding of entrepreneurship.

We also introduce a new field that lies at the intersection of scientific management and entrepreneurship (Figure 1). Figure 1 visually depicts the two fields of entrepreneurship and scientific management. The overlapping domain that lies at the intersection of these two fields is the area that represents the new field of scientific entrepreneurial management. The identification of new fields that lie at the crossroads of two established research paths is not new. Prior scholars have used this approach to similarly introduce new fields such as international entrepreneurship (McDougal & Oviatt, 2000). The potential topics that may be included in this new field is provided and discussed later in Table 1.

The paper is, to our knowledge, the first in its attempt to link Taylor's contributions to entrepreneurial practice. Though entrepreneurship is a relatively new entrant in the field of management, and was, needless to say, nonexistent as a discipline during

Taylor's time, we find strong resonance and reflection of scientific management principles in the practice of entrepreneurship. As such, a century later, Taylor's work is still valuable and relevant to our understanding of business and management in a variety of contexts.

Figure 1: *Scientific Entrepreneurial Management lies at the intersection of Scientific Management and Entrepreneurship*



Quest for Efficiencies: Scientific Management and Entrepreneurship

In both scientific management and entrepreneurship, a major factor that drives success is the level of efficiency, or the efficient use of resources. Scientific management assists in the evaluation of internal and external factors so that efficient operations may be conducted within the organization. Hence, it allows businesses to earn a larger income from a given set of resources. This significant rise in income is made possible by resource conserving management and very efficient operational processes (Mohanty, 1993).

Taylor acknowledges that the restriction in output in the Midvale Steel Company was a result of inefficiencies that could easily have been corrected by scientific management of the work and workers (Wren, 1994). Both systematic and natural "soldiering" were identified as sources of inefficiencies in the worker that could be overcome by the application of differential pay rate systems for "first class" work (Taylor, 1903; Wagner-Tsukamoto, 2007).

Since the workers at Midvale commonly understood and believed in the "lump of labor" theory, they felt that working more quickly or doing more reduced the total work available, thus reducing their ability to find jobs for themselves or other fellow workers. By altering the wage system and appropriately structuring the incentives for highly efficient workers, Taylor was effective in creating a mental revolution on the part of both the worker and management (Locke, 1982; Wrege & Greenwood, 1991). This brought about a new mindset that propelled the way to greater economic prosperity for both the workers and management.

Taylor's quest for efficiencies did not stop at overcoming mental resistance, but went further to address the operational details in another well known experiment (i.e., the shoveling experiments). The goal of the shoveling experiments was to come up with the maximum/ideal weight that should be borne in a shovel. This optimal weight would allow a "first class man" to be most productive for the company. Though the optimal weight may cause tiredness, it would not lead to exhaustion of the worker. With systematic methods and observations of time and motion, scientific management came up with the most efficient, ergonomic, and economic set of activities that if performed in the proper sequence and timing, would potentially increase output several times over (Locke, 1982; Wagner-Tsukamoto, 2007). No doubt, such rigorous application of scientific principles to work activities was a significant departure from the prevalent "rule of thumb" or traditional approaches to management (Taylor, 1911; Locke, 1982; Schachter, 2010). The presentation of comparative evidence and data on both scientific and traditional approaches convincingly showed the superiority of the scientific approach (Drucker, 1976; Wren, 1994). Businesses that wanted to reap the benefits of greater productivity with the same or lesser resources, quickly adopted Taylor's principles, despite initial skepticism and opposition (Schachter, 2010). Thus, Taylor was successful in his quest for greater efficiencies in the workplace, and for introducing a scientific basis for the conduct of management.

Interestingly, Taylor's experimentation, observation, and application of the principles of scientific management seemed to occur primarily in one industrial context, i.e., large, established manufacturing plants such as the Midvale Steel Company and the Bethlehem Steel Company. Nevertheless, as pointed out by Taylor himself, scientific management was generalizable to other contexts as well (Taylor, 1911; Locke, 1982; Guillen, 1997). Smaller businesses and entrepreneurial firms can likewise benefit in equal measure and experience greater efficiencies by the efficient management of resources as espoused by the principles of scientific management.

In the entrepreneurial context, most new businesses and startups are small in size at the time of founding, and often face liabilities of size (Stinchcombe, 1965). In addition, liabilities of newness are another burden that these firms must endure during the initial stages (Stinchcombe, 1965). They are also usually constrained in the availability of resources, having less access to financial, technological, and human capital than established, and larger firms. The absence of slack resources puts these entrepreneurial businesses in an environment of constrained resources. The entrepreneur, in order to be successful, must ensure that productivity is not hampered by the lack of adequate resources. The quest for efficiencies therefore has a much more sharpened and focused edge in entrepreneurial businesses. Both labor and management are often located in a single person, the entrepreneur owner, who tries to orchestrate firm performance single handedly, or with minimal help. Efficiency becomes the mantra that allows the entrepreneur to operate under constrained resources. By efficiently managing available resources (time, money, materials, labor) in unique and inimitable ways, entrepreneurs are able to deal with competitive pressures and grow into successful businesses. On the other hand, a large percentage of new startups fail because they are unable to operate with the desired efficiency and productivity levels of their competitors who may have the benefits of slack or richer resource environments (Aldrich & Auster, 1986; Carroll, 1993; Wu et al., 2008). The successful quest for continuous efficiencies therefore, may be said to characterize successful entrepreneurial businesses.

Table 1: *Linking Scientific Management and Entrepreneurship*

Conceptual Similarities	Examples in Scientific Management	Examples in Entrepreneurship
Developing a science for each element of each person's work	Optimal sequence of steps (Taylor, 1911*); Objective method for efficiency (Locke, 1982*); Mapping organizational efficiencies (Wagner-Tsukamoto, 2007*)	Efficiency and quality benchmarking in franchising (Kidwell & Nygaard, 2011); franchising as an entrepreneurial partnership to increase speed, scale, and scope of a workable system (Grewal et al., 2011; Buzza & Mozca, 2009); HR practices and role requirements directed toward increasing customer satisfaction (Voss, Frankwick, & Chakarborty, 2002*)
Workers are scientifically selected and trained	Right man for the right job (Taylor, 1903*; Lock 1982*); Tasks Identification and specification (Taylor, 1911*; Freeman, 1996*); Understanding human resource needs (Jones, 2000*)	Staffing for emerging and growing firms (Short et al., 2010); identifying potential candidates career potential with the firm (Lee & Vankataraman, 2006); Trade name membership to increase employee training (Litz & Stewart, 2000); someone is clearly responsible for all important processes (Sayles & Stewart, 1995*)
Cooperation between management and worker so that work is done in accordance with the developed science	Cooperation between managers and workers (Taylor, 1911*); Conflict resolution and overcoming opportunism (Wanger-Tsukamoto, 2007, 2008*)	Building social networks (Greve & Salaff, 2003); empowering employees through corporate entrepreneurship for organizational effectiveness (Sundbo, 1999)

* Specified link or mention to scientific management in article

Among other things, scientific management may be viewed as a systematic method that involves painstakingly developing a science for each element of an individual's task, then scientifically selecting and training workers for each position and roles, and finally, ensuring cooperation between management and workers so that the scientific processes are duly followed to accomplish each task. Table 1 links these three higher-order concepts of scientific management with similar concepts that are valued and sought after entrepreneurship. Here we provide examples from entrepreneurship research that involve the three scientific management processes for a) increasing effectiveness and efficiencies (Kidwell & Nygaard, 2011; Grenwal et al., 2011; Buzza & Mozca, 2009; Voss, Frankwick & Chakarborty, 2002); b) formalized procedures for hiring and training the right person (Short et al., 2009; Lee & Venkataraman, 2006; Litz & Stewart, 2002; Sayles & Stewart, 1995); and c) developing cooperative relationships between employees and the entrepreneur (Greve & Salaff, 2003; Sundbo, 1999). We provide these examples to support our vision of a new field of scientific entrepreneurial management, and to indicate the potential topics that may be included in the zone of intersection between the two fields of entrepreneurship and scientific management previously depicted in Figure 1.

Given the similarities of objectives in both scientific and entrepreneurial management, it is surprising that extant scholarly research has failed to address this area of overlap. We close this gap in the literature by identifying two specific examples of entrepreneurial behavior that most closely embody the principles of scientific management. By taking this novel approach, we hope to stimulate a greater appreciation of the relevance and implications of Taylor's work to entrepreneurship.

Bricolage and Scientific Management

Levi-Strauss (1966) first introduced the idea of bricolage as a way of describing how humans relate to their environments. The idea of bricolage has been adapted and examined more extensively in management literature as a resource management process (Ciborra, 1996; Duymedjian & Ruling, 2010). The original notion of the concept developed by Levi-Strauss (1966) was to make do with whatever is available, and this description has been adopted by subsequent researchers (Duymedjian & Ruling, 2010). For example, bricolage has been discussed in relation to improvisation (Weick, 1993; Orlikowski, 1996; Ciborra, 1996; Moorman & Miner, 1998), sensemaking (Weick, 1993), entrepreneurship (Baker, Miner & Eesley, 2003; Baker & Nelson, 2005), technological systems (Ciborra, 1996; Orlikowski, 2000), and innovation (Garud & Karnoe, 2003).

The central concepts in bricolage include "making do," "improvisation," and "a refusal to be constrained by limitations" (Di Domenico, Haugh & Tracey, 2010). The centrality of bricolage to entrepreneurs can be seen from the fact that in addition to improvisational effects on some foundings, it permeates a wide range of entrepreneurial activity in the form of strategic, tactical, and network improvisation (Baker et al., 2003). Baker and Nelson (2005) suggested taking a constructivist approach to resource environments would be more beneficial to understanding entrepreneurial behavior, since bricoleurs refuse to enact limitations imposed by resource environments. That is, small entrepreneurial firms recognized and exploited opportunities from various inputs that were ignored or rejected by other firms.

For clarity, we adopt an integrated definition of the term bricolage as "making do by applying combinations of the resources at hand to new problems and opportunities (Baker & Nelson, 2005, p. 333). This definition is useful as it allows for further discussion of bricolage as an organizational process (Ciborra, 2002) for managing resources.

Environments change and organizations are not static (Ciborra, 1996), therefore organizations should be concerned with the timeliness with which they are able to react and recombine resources to meet those changes (Ciborra, 1996). In meeting those demands and reacting to environmental uncertainties organizations work within the constraints of a finite amount of resources (Duymedjian & Ruling, 2010). To overcome those constraints, organizations have several choices such as resource-seeking, refusing to act at all (Baker et al., 2003) or following a process of bricolage, making do or recombining resources in their inventory (Ciborra, 1996). The resource management process is characterized as having three components: resource inventory, resource bundling and resource leveraging (Simon & Hitt, 2003).

The process of bricolage is said to be a process where the actor has intimate knowledge (Ciborra, 1996) of their inventory "repertoire" (Levi-Strauss, 1966) and will assemble, often heterogeneous (Duymedjian & Ruling, 2010) resources. While the organization does have intimate knowledge of their resources and the identity of the platform (Ciborra, 1996) for which they operate, the assembly and recombination of resources is not a perfect process. It is a process of trial and error and often continual incremental adjustments to find the right fit for the problem at hand (Simon, 1997). Once the process of recombining resources addresses the problem, the process stops (Duymedjian & Ruling, 2010).

Baker et al. (2003) and Baker and Nelson (2005) identified the importance bricolage has for the entrepreneur's process of organization growth. For entrepreneurial organizations that are actively 'fiddling' (Ciborra, 1996) or recombining existing resources they are achieving several positive outcomes. First, the organization is involved in a learning process that will help it understand more about its own resources and how it can effectively compete in the environment (Fernandes, 2005). Second, they are finding new and possible beneficial responses to this innovative recombination of resources from the environment. This is a demarcation from the view that strategies and resource utilization occur primarily from an a priori idea (Duymedjian & Ruling, 2010). Network bricolage (Baker et al., 2003) occurs when organizations mobilize other actors in their existing networks to address the uncertainties they face in common. This idea of network bricolage is different than the entrepreneur's typical use of networking tactics to obtain resources. In contrast, they view network contacts as a primary 'on hand' resource to be utilized (Baker et al., 2003). Network bricolage is another area of resource management that entrepreneurial organizations seem to derive benefit from.

According to Weick (2001), successful bricolage in organizations requires the following conditions: intimate knowledge of resources, careful observation and listening, trusting one's ideas, and self-correcting structures with feedback. This fourfold description fits scientific management rather closely. Taylor's approach involved a thorough and deep understanding of the resources at hand, especially human resources. He stressed the importance of knowing what each worker was capable of, since effectiveness of the technique was dependent on finding the "right man for the right job." His selection of "Schmidt," a very tall, large and energetic man, was extremely critical for illustrative purposes. Had a less capable man been chosen, it would have been unlikely to get the results (increased productivity) that scientific management promised.

Taylor's scientific method involved careful observation of the men at Midvale Steel. One well-known experiment was the loading of pig iron ingots onto railroad carts. A systematic analysis of the time and motions required for each action was conducted, so as to come up with the optimal sequence of steps that were required to perform the task of loading pig iron ingots for transportation. The third aspect of bricolage, trusting oneself, is true of scientific management's emphasis on the philosophy of mental revolutions. Taylor cautions against mistaking "the mechanism of management for its essence, or underlying philosophy" (Taylor, 1911, p. 128). An essential component of Taylor's principles is the trust and belief that prosperity is ensured for both the worker and management. Each worker was told very clearly what the expectations were for a "first class man." Further, if these expectations were met, they could trust management to pay them "first class wages." Management likewise could trust that workers understood and behaved as per this arrangement, and disputes were minimized. Both management and workers trusted that greater efficiency was in their best interest. Without this attitudinal buy-in to scientific management, companies would find it very difficult to ensure commitment or realize the success of heightened efficiencies.

The fourth aspect of bricolage, self-correcting structures with feedback, is also deeply evocative of scientific management. Once expectations for the differential pay rate system were set up and formalized, each worker received feedback on a daily basis regarding their performance the previous day. Color coded slips (white which indicated everything was okay, and yellow which indicated that they must do better or they would be shifted to another class of work) were placed in each worker's special pigeonhole. The ingenious use of colored slips ensured that the illiterate workers knew without reading, whether their work was above or below par, and allowed for self correcting behaviors as a result of their performance feedback.

Scientific management reflected a formalized and science-based system of management. Similarly, bricolage can also (but need not always) be considered as a formal system. Though bricolage may initially begin informally, over time it is likely to become routinized and explicitly encoded into behavioral and operational processes in a formal manner. Engaging the process of bricolage not only helps to build competitive advantages through the identification of new and creative outcomes, but it can also be a formalized process (Duymedjian & Ruling, 2010). The outcomes of bricolage can be transformed into a functional structure through codification of arrangements, effectively turning a process of trial and error into an organization routine (Ciborra, 1996; Duymedjian & Ruling, 2010). This formalization process is a way for organizations to exploit the value of the practical arrangement, and scientific management has much to contribute to the systematization of this process. Bricolage (like scientific management) is a useful management tool, that is both effective and beneficial (Duymedjian & Ruling, 2010).

Table 2 builds upon Weick's (2001) fourfold classification of bricolage to identify the conceptual similarities between scientific management and bricolage. In this table we have summarized the key research that showcases each of these four aspects in both scientific management and entrepreneurship. For example, we can see that scientific management is concerned with knowledge of firm specific resources in terms of human capital (Taylor, 1903; Locke, 1982; Jones, 2000). Similarly, knowledge of resources is central to bricolage in ensuring growth (Jarillo, 1989; Baron & Markman, 2003) and resource mobilization (DiMaggio, 1988; Battilana & Leca, 2009). Further scientific management is concerned with observation and efficiencies (Wagner-Tsukamoto, 2007) and in entrepreneurship as well, there is great focus on organizing activities and sequences (Delmar & Shane, 2004; Carter, Gartner & Reynolds, 1996). In terms of "trusting one's ideas," we observe that scientific management has focused on cooperation (Taylor, 1911) and conflict resolution (Wanger-Tsukamoto, 2007). Likewise, we find that entrepreneurship research considers cooperation (Aldrich, 2000; Wu et al., 2008) and self-confidence (Kollinger, Minniti & Schade, 2007) as important concepts. Finally, both scientific management and entrepreneurship research identifies the need for examining feedback through goals (Locke, 1978) and entrepreneurial hindsight and exit (Cassar & Craig, 2009; Wennberg et al., 2010). The table also indicates research articles that identify or explicitly mention scientific management. We provide this summarized research table to show evidence from prior research that both bricolage and scientific management have conceptual links that could be further explored.

Table 2: *Linking Scientific Management and Bricolage*

Conceptual Similarities	Examples in Scientific Management	Examples of Bricolage in Entrepreneurship
Knowledge of Resources	Right man for the right job (Taylor, 1903*; Lock 1982*); Tasks Identification and specification (Taylor, 1911*; Freeman, 1996*); Understanding human resource needs (Jones, 2000*)	Entrepreneurial growth and external resources (Jarillo, 1989); Necessity of resources (DiMaggio, 1988); Need for resource mobilization (Battilana & Leca, 2009); Role of social capital and entrepreneurial success (Baron & Markman, 2003)
Careful Observation and Listening	Optimal sequence of steps (Taylor, 1911*); Objective method for efficiency (Locke, 1982*); Mapping organizational efficiencies (Wagner-Tsukamoto, 2007*)	Start-up behaviors (Gatewood, Shaver, & Gartner, 1995); Start-up event sequences (Carter, Gartner, & Reynolds, 1996); Organizing activities (Delmar & Shane, 2004)
Trusting One's Ideas	Cooperation between managers and workers (Taylor, 1911*); Conflict resolution and overcoming opportunism (Wanger-Tsukamoto, 2007*, 2008*)	Entrepreneurial Self-confidence (Koellinger, Minniti, & Schade, 2007); Building networks (Aldrich, 2000); Entrepreneurial trust (Welter & Smallbone, 2006);Cooperative networks (Wu, Wang, Chen, & Pan, 2008);
Self-Correcting Structures with Feedback	Goal setting behaviors and feedback (Lock, 1978; Locke, Shaw, Saari, & Latham, 1981; Locke, 1982)	Hindsight and nascent venture activity (Cassar & Craig, 2009); Entrepreneurial Discontinuance (Liao, Welsch, & Moutray, 2008); Drivers for Venture Exit (Wennberg, Wiklund, DeTienne, & Cardon, 2010)

* Specified link or mention to scientific management in article

Bootstrapping and Scientific Management

Consistent with both the resource-based view (Barney, 1991) and the resource dependence theory (Pfeffer & Salancik, 1978) entrepreneurs need to acquire, or have access to necessary resources within their firms to grow and survive (Ebben, 2009). However, small and entrepreneurial firms operate in resource constrained environments. For example, many startups experience significant difficulty in gaining access to necessary financial capital from formal avenues such as banks or venture capitalists (Winborg & Landstrom, 2001).

One way to effectively overcome resource constraints is through bootstrapping. Simply put, bootstrapping allows business operations to continue without the aid of external financial resources or aid. “Bootstrapping is entrepreneurship in its purest form. It’s the transformation of human capital into financial capital, sweat equity into bankable equity” (Gendron, 1999, pp. 11-12). That’s what we mean when we talk about “creating value” (Gendron, 1999, pp. 11-12). Bootstrapping includes the idea of “meeting the need for resources without relying on long-term external finance from debt holders or new owners” (Winborg & Landstrom, 2001). This strategy of bootstrapping can be separated into two forms; first, creating ways to acquire access to necessary financial capital through informal and alternative methods. The second is to minimize or eliminate the actual need for financing by securing resources at minimal or no cost (Harrison, Mason & Girling, 2004). While bootstrapping is not explicitly associated with financial resources (as many different types of resources are needed), financial resources are often looked at as one of the most important because they enable the acquisition of those other needed resources (Bhide, 2000; Brush et al., 2006). This is one of the reasons that most research to-date has focused on financial bootstrapping strategies and their effects on the firm (Freear, Sohl & Wetzel, 1995; Winborg & Landstrom, 2001; Harrison et al., 2004; Carter & van Auken, 2005; Ebben & Johnson, 2006; Ebben, 2009).

The resource constraints faced by start-ups and small firms is in part due to the presence of information asymmetries and high transaction costs (Cassar, 2004). Information asymmetries have to do with the difficulty the entrepreneur has in articulating the potential of the company to formal investors (Winborg & Lanstrom, 2001) and lack of available public information (Carpenter & Petersen, 2002) which results in formal investing institutions considering it as a risky investment (Ebben & Johnson, 2006). These information asymmetries may be two-sided as financial institutions might have information regarding the industry as a whole that the individual entrepreneur does not have (Winborg & Landstrom, 2001). Transaction costs are often high because it can be costly for financial institutions to provide smaller sized loans or investments. Therefore, those increased costs are passed onto the entrepreneur (Ebben & Johnson, 2006). Bootstrapping in these cases then becomes the strategy of necessity and not of choice (Roberts, 2003; Cole et al., 2005).

Through empirical evidence researchers have identified four distinct classifications of bootstrapping that different strategies and methods fall under (Winborg & Landstrom, 2001); (1) customer-related, (2) delaying payments, (3) owner-related financing and resource, and (4) joint-utilization of resources with other firms. Customer-related methods include obtaining advanced payments, interest on overdue invoices, and not doing business with customers that make late payments. Delaying payments include negotiating longer terms with suppliers or possibly leasing equipment. Owner-related methods would include the owner providing the financial resources from savings, personal loans by the owner, personal credit cards or loans from family and friends. The joint-utilization of resources could involve the sharing of employees and/or assets with other firms.

Following Winborg and Landstrom's (2001) fourfold classification of bootstrapping, we find that both entrepreneurship and scientific management have significant conceptual similarities that can be identified from prior research. From a scientific management perspective we can locate specific formalized areas of management research relating to each of the four bootstrapping classifications. Some of these examples often directly discussed the use of scientific management (Drummond, 1995; Havs, 1994; Jeacle, 2004, Richardson, 1995) to formalize organizational processes in order to increase efficiency and effectiveness. Linking these concepts with entrepreneurial bootstrapping helps our understanding of how entrepreneurs often use formalized processes even when they are attempting to find innovative and creative means to survive and succeed. Thus, scientific management techniques are applicable and useful in the context of entrepreneurial bootstrapping. Research has also examined when and with what types of firms these different methods of bootstrapping are utilized. For example, both Freear et al. (1995) and Harrison et al. (2004) found that software companies (in the U.S. and the U.K.) used bootstrapping techniques for both business and product development situations. The use of bootstrapping techniques throughout the life of the company was also examined by Ebben and Johnson (2006). Brush et al. (2006) found that female-run businesses used different bootstrapping methods based on the different life stages of the business, because different techniques were needed to meet varying demands as the companies grew. Ebben (2009) found that firms that were highly leveraged, had lower liquidity, and lower profitability were more likely to utilize one type of bootstrapping technique over another. The industry context and environment were found to affect the type of bootstrapping methods used and the investment decisions that were made by entrepreneurs (Van Auken, 2005; Ekanem, 2005).

Other studies have examined and identified different types of bootstrappers (Lahm, 2005). They include discouraged borrowers that have good credit and could potentially obtain financing through traditional formal methods, but think they will get rejected and therefore do not attempt it (Kon & Storey, 2003). Some entrepreneurs, having the desire for autonomy and privacy, do not do what is required to relinquish control or have some sort of oversight because of the financial obligations (Fried & Hisrch, 1995). Other entrepreneurs pride themselves on being self-sufficient and want to avoid any strings attached with borrowing, while other entrepreneurs look at the entrepreneurial process as a game and take pride in growing a business on their own (Lahm, 2005).

Table 3: *Linking Scientific Management and Bootstrapping*

Conceptual Similarities	Examples in Scientific Management	Examples of Bootstrapping in Entrepreneurship
Customer-Related	Improving customer management and relationships through controlling and improving processes (Snee, 2006); Formal processes of Total Quality Management (TQM) for customer management (Drummond, 1995*); stabilizing customer relationships through Quality Improvement methodologies (Hays, 1994*)	Obtaining advanced payments from customers (Winborg & Landstrom, 2001); including interest on overdue invoices (Ebben & Johnson, 2006); cease business relations with late payment customers (Harrison, Mason, & Girling, 2004)
Delaying Payments	Inventory valuation and management procedures (Jeacle, 2004*); Formalized process of supply chain management (Richardson, 1995*)	Lease equipment (Carter, Gartner, & Reynolds, 1996); Supply chain management (Madu, Kuei, Chow, Ndubisi, 2011); Inventory management (Carraher et al., 2006)
Owner-related Financing	Strategic financial planning and financial controls (Brinckmann, Salomo, & Gemuenden, 2011); Implementation of financial management systems (Coelho & Matias, 2010)	Financing through use of personal savings (Carter & Van Auken, 2005); Leveraging capital from family and friends (Au & Kwan (2009); Use of personal credit (Van Auken & Neeley, 2000)
Joint utilization of Resources with other Firms	Formalized interorganizational relationships (Todeva & Knoke, 2005); Identifying processes or steps to get the most out of collaborative arrangements (Hamel, Doz, Prahalad, 1989)	Knowledge and resource sharing (Vilamos, Halkos, & Tzeremes, 2009); Entrepreneurial teams and joint ventures (Lacobucci & Rosa, 2010)

* Specified link or mention to scientific management in article

Bootstrapping has been characterized as part of the creative problem solving process for the emergent nature of entrepreneurship and again is a necessity (Bhide, 1992). Luck or momentum also can play a role, where the business takes on a life of its own contributing to the success of the business (Lahm, 2005). Finally, bootstrapping is often the speedier and more convenient way to gain access to large amounts of capital (e.g. through credit cards) (Cole et al., 2005). Entrepreneurs, through bootstrapping, can use their know-how, imagination and hard work as a substitute for external financial capital in an effort to grow and survive (Mamis, 1992).

There appear to be two view points of the actual effects that bootstrapping has on the performance of the firm (Ebben, 2009). First, some view bootstrapping as a negative and believe it should only be used a last resort (Binks & Ennew, 1996; Bruno, Leidecker & Harder 1987; Stancill, 1986). Resource dependency theory and resource-based views affirm that resources are necessary for competitive advantages, growth and survival. When firms utilize bootstrapping strategies, they lack access to financing, which puts an immediate constraint on survival, growth, and financial performance. This view has been empirically supported (Bechetti & Trovato, 2002; Bamford, Dean & McDougall, 2000; Cooper et al., 1994; Chandler & Hanks, 1994; Bruderl, Preisendorfer & Ziegler, 1992; Duchesneau & Gartner, 1990) and most recently by Ebben (2009) where firms were only engaging in bootstrapping out of necessity and not as a strategic decision, which often caused negative financial effects.

An opposing view states that bootstrapping may help firms succeed (Bhide, 1992; Timmons, 1999). One idea is that new entrepreneurs are inexperienced in investing financial capital and therefore increase costs without generating sufficient returns (Barker, 2000). Another benefit is that bootstrapping helps make firms more efficient as it teaches the entrepreneur how to identify and be concerned with how every dollar is spent while also ensuring nothing is being wasted (Timmons, 1999). Bootstrapping therefore has the effect of helping to make the firm lean (Timmons, 1999; Harrison et al., 2004). It is recommended that more research examine the effects of bootstrapping methods on performance and survival.

While the idea of bootstrapping has been discussed often from practical points of view (Gendron, 1999; Lahm, 2005; Lahm & Little, 2005), formal research examining the effects of bootstrapping on entrepreneurial behavior and firm success is lacking (Winborg & Landstrom, 2001; Harrison et al., 2004; Lahm & Little, 2005; Ebben & Johnson, 2006; Ebben, 2009; Lam, 2009). Even current entrepreneurial text books often only provide a few paragraphs on the idea of bootstrapping with more emphasis on traditional and formal methods of obtaining financing (Lahm & Little, 2005; Zimmerer, Scarborough & Wilson, 2008). Though not specifically discussed, the notion of bootstrapping is often implied in entrepreneurship (Lam, 2009), such as examining other sources of financing from family and friends to the business owner's savings and credit cards (Hamilton, 2001; Lam 2009). Another area that is problematic for the study of bootstrapping is that most studies are exploratory in nature and the conceptual framework and theoretical development is significantly lacking (Lam, 2009). From the above review of extant research, it is clear that "bootstrapping is a phenomenon which deserves more attention in future research" (Winborg & Lanstrom, 2001, p. 235). From a resource management perspective, bootstrapping can promote lean organizations and maximize internal efficiencies with limited resource sets, while simultaneously delivering desired levels of productivity. Scientific management can contribute to our understanding of bootstrapping by applying the same systematic observation and principles to bootstrapping behavior.

What is lacking in our understanding of the bootstrapping phenomenon can be addressed to a great extent by the methodology followed by Taylor. Table 3 indicates potential areas of overlap between bootstrapping and scientific management based on prior research. These potential areas have much unrealized promise that would need to be examined further in future research.

We therefore argue that entrepreneurial bootstrapping stands to benefit greatly from a fine tuned application of relevant scientific management principles. We call on future research to address this important application of Taylor's work to benefit entrepreneurs and small businesses. A systematic observation of entrepreneurial bootstrapping, coupled with scientific conclusions, the creation of formulas for maximum efficiency with minimal resources, etc. are all areas where scientific management can be of great relevance. Though entrepreneurship as a formal discipline did not exist during Taylor's time, the techniques of scientific management do bear surprising similarities to entrepreneurial behaviors such as bootstrapping. The motivations of both stem from the quest for higher efficiencies and higher prosperity. The promise of scientific management to bootstrapping is yet to be realized. Hopefully future research will be directed at this yet to be explored area. It is likely that with focused attention on the scientific management basis of bootstrapping, we may see a new area of scientific entrepreneurial management emerge and engage future scholarly interest and investigation.

Implications and Relevance of Taylor to Entrepreneurship

The emergence of scientific management occurred during a period of national crisis, with President Roosevelt calling for a stoppage of resource wastage and raising of national efficiencies. With the advent of scientific management, the industrial and manufacturing sectors of the economy saw unprecedented increases in productivity and consequent raises in national prosperity and wealth (Drucker, 1976; Locke, 1982; Simha & Lemak, 2010).

Entrepreneurship has been recognized to have made significant contributions to national wealth and prosperity (Schumpeter, 1950; Dubini, 1989; Quadrini, 1999). As such, governments seek to improve the level of entrepreneurship and new firm start-ups by providing a number of incentives. While much scholarly attention has been devoted to understanding entrepreneurship, its antecedents, causes, outcomes, and covariates, some areas demand more systematic inquiry. Among these are the unique entrepreneurial phenomena of bricolage and bootstrapping.

While most entrepreneurs instinctively, intuitively, or unconsciously adopt bricolage or bootstrapping as efficient ways to manage resource constraints, they are unable to articulate (beyond their particular resource environments) the principles that guide them through such decisions. Further, due to the successful use of bricolage and bootstrapping, these entrepreneurs continue to engage in these behaviors due to their beneficial effects on productivity, efficiency and profitability. Such knowledge remains embedded in the entrepreneur who discovers through constant "tinkering" what works best under specific situations.

Rarely is this knowledge externalized in a manner that can be easily adopted or applied by other entrepreneurs. Rather each entrepreneur must begin the journey again, and discover through trial and error what resource management techniques work best. Hence, there is some "reinventing of the wheel" with each entrepreneurial journey that can easily be minimized. Perhaps this is the reason why the myth that entrepreneurs are born, or that entrepreneurship cannot be taught seems to perpetuate. Prior to the onset of scientific management, rules of thumb, or tradition guided most managerial practices. The replacement of scientific principles was revolutionary, and much credit is due to scholars like Taylor who contributed to the scientific basis of management.

With the application of the same scientific rigor, observation and study of entrepreneurial phenomena such as bricolage and bootstrapping, much would be gained in the form of rules, procedures, sequences, and activities that could potentially generalize to other entrepreneurial contexts. It is likely that such examinations could lead to Scientific Entrepreneurial Management, a new field that lies at the intersection of scientific management and entrepreneurship.

References

Aldrich, H. & Auster, E. (1986). Even dwarfs started small: Liabilities of age and size and their strategic implications. *Research in Organizational Behavior, 8*: 165-198.

Baker, T. & Nelson, R.E. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative Science Quarterly, 50*: 329–366.

Baker, T., Miner, A.S. & Eesley, D.T. (2003). Improvising firms: Bricolage, account giving, and improvisational competency in the founding process. *Research Policy, 32*: 255–276.

Bamford, C., Dean, T. & McDougall, P. (2000). An examination of the impact of initial founding conditions and decisions on the performance of new bank start-ups. *Journal of Business Venturing, 15*: 253-77.

Barker, E. (2002). Start with nothing. *Inc., 24*: 66-72.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*: 99-120.

Baron, R. A. & Markman, G. D. (2003). Beyond social capital: the role of entrepreneurs' social competence in their financial success. *Journal of Business Venturing, 18*(1): 41-60

Battilana, J. & Leca, B. (2009). The role of resources in institutional entrepreneurship: Insights for an approach to strategic management combining agency and institutions. In L.A. Costanzo & R.B. MacKay (Eds.), *Handbook of research on strategy and foresight*: 260–274. Norwell, MA: Kluwer.

Bechetti, L. & Trovato, G. (2002).The determinants of growth for small and medium sized firms: the role of the availability of external finance. *Small Business Economics, 19*: 291-306.

Bhide, A. (1992). Bootstrap finance: The art of start-ups. *Harvard Business Review, 70*: 109-117.

Bhide, A. (2000) *The Origin and Evolution of New Businesses*. New York: Oxford University Press.

Binks, M. & Ennew, C. (1996). Growing firms and the credit constraint. *Small Business*

Economics, 8: 17-25.
Bruderl, J., Preisendorfer, P. and Ziegler, R. (1992). Survival chances of newly founded business organizations. *American Sociological Review, 57*: 227-42.
Bruno, A., Leidecker, J. & Harder, J. (1987). Why firms fail. *Business Horizons, 30*: 50-8.
Brush, C. G.,Greene, P. G. & Hart, M.M. (2001). From initial idea to unique advantage: the entrepreneurial challenge of constructing a resource base. *Academy of Management Executive, 15*(1): 64–80.
Brush, C., Carter, N., Gatewood, E., Greene, P. & Hart, M. (2006). The use of bootstrapping by women entrepreneurs in positioning for growth. *Venture Capital, 8*(1): 15-31.
Buzza, J. & Mosca, J. (2009). Create the plan, work the plan: A look at why the independent business owner has trouble calling a franchisee a true entrepreneur. *American Journal of Business Education, 2*(7): 113-118.
Carroll, G. (1993). A sociological view on why firms differ. *Strategic Management Journal, 14*(4):237-249.
Carpenter, R. & Petersen, B. (2002). Is the growth of small firms constrained by internal finance? *Review of Economics and Statistics, 84*: 298–309.
Carter, N. M., Gartner, W. B. & Reynolds, P. D. (1996). Exploring start-up event sequences. *Journal of Business Venturing, 11*(3): 151-166.
Carter, R. & Van Auken, H. (2005). Bootstrap financing and owners' perceptions of their business constraints and opportunities. *Entrepreneurship and Regional Development, 17*(2): 129-144.
Cassar, G. (2001). The financing and capital structure of business start-ups: the importance of asset structure. In Bygrave, W., Autio E., Brush, C., Davidsson, P., Greene, P., Reynolds, P. & Sapienza, H. (Eds.), *Frontiers of Entrepreneurship Research* (pp. 452 – 263). Wellesley, MA: Babson College.
Cassar, G. (2004).The financing of business start-ups. *Journal of Business Venturing, 19*: 261-83.
Cassar, G. & Craig, J. (2009). An investigation of hindsight bias in nascent venture activity. *Journal of Business Venturing, 24*(2): 149-164.
Chandler, G. & Hanks, S. (1994). Market attractiveness, resource-based capabilities, venture strategies, and venture performance. *Journal of Business Venturing, 9*: 331-50.
Ciborra, C. (1996). The platform organization: recombining strategies, structures, and surprises. *Organization Science, 7*(2): 103- 118.
Cole, J.D., Lahm, R.J., Little, H.T. & Seipel, S.J. (2005). Credit cards as a source of start-up capital and ongoing capital management. Paper presented at the 2005 *International Council for Small Business World Conference,* Washinton, D.C.
Cooper, A., Gimeno-Gascon, F.J. & Woo, C. (1994). Initial human and financial capital as predictors of new venture performance. *Journal of Business Venturing, 9*: 371-95.
Delmar, F. & Shane, S. (2004). Legitimating first: organizing activities and the survival of new ventures. *Journal of Business Venturing, 19*(3): 385-410.
Di Domenico, M., Haugh, H. & Tracey, P. (2010). Social bricolage: theorizing social value creation in social enterprises. *Entrepreneurship Theory and Practice, 34*(4): 681.
DiMaggio, P. (1988). Interest and agency in institutional theory. In Zucker, L. (Ed.), *Institutional patterns and organizations: Culture and environment:* 3-22. Cambridge,

MA: Ballinger.
Drucker, P. F. (1976). The coming rediscovery of scientific management. *Conference Board Record, 13*(6): 23-27.
Drummond, H. (1995). Beyond quality. *Journal of General Management, 20*(4): 68.
Dubini, P. (1989). The influence of motivations and environments on business start-ups: Some hints for public policies. *Journal of Business Venturing, 4*(1): 11-26.
Duchesneau, D. & Gartner, W. (1990). A profile of new venture success and failure in an emerging industry. *Journal of Business Venturing, 5*: 297-312.
Duymedjian, R. & Ruling, C. (2010). Towards a foundation of bricolage in organization and management theory. *Organization Studies, 31*(2): 133- 151.
Ebben, J.J. (2009). Bootstrapping and the financial condition of small firms. *International Journal of Entrepreneurial Behavior & Research, 15*(4): 346-363.
Ebben, J. & Johnson, A. (2006). Bootstrapping in small firms: an empirical analysis of change of overtime. *Journal of Business Venturing, 21*: 851-865.
Eisenhardt, K. & Martin, J. (2000). Dynamic capabilities: what are they? *Strategic Management Journal, 21:* 1105-1122.
Ekanem, I. (2005). 'Bootstrapping': the investment decision-making process in small firms. *The British Accounting Review, 37*: 299-318.
Freear, J., Sohl, J.E. & Wetzel, W.E. Jr. (1995). Who bankrolls software entrepreneurs?. Paper at the *Babson College Entrepreneurship Research Conference*, April 9-13, 1995. London, UK.
Fried, V.H. & Hisrich, R.D. (1995). The venture capitalist: a relationship investor. *California Management Review, 37*(2): 101.
Garud, R. & Karnøe, P. (2003). Bricolage versus breakthrough: Distributed and embedded agency in technology entrepreneurship. *Research Policy, 32*: 277–300.
Gendron, G. (1999). *The annals of bootstrapping. Inc., 21*: 11-12.
Greve, A. & Salaff, J. (2003). Social networks and entrepeneurship. *Entrepreneurship Theory and Practice, 28*(1): 1-22.
Guillen, M.F. (1997). Scientific Management's lost aesthetic: architecture, organization, and theTaylorized beauty of the mechanical. *Administrative Science Quarterly, 42*: 682-715.
Hamilton, R.H. (2001). E-commerce new venture performance: how funding impacts culture. *Electronic Applications and Policy, 11*(4): 277-285.
Harrison, R., Mason, C. & Girling, P. (2004). Financial bootstrapping and venture development in the software industry. *Entrepreneurship and Regional Development, 16*(3): 307 – 333.
Helfat, C.E. (1997). Know-how and asset complementarity and dynamic capability accumulation: the case of R&D. *Strategic Management Journa, 18*(5): 339–360.
Jarillo, C. (1989). Entreprenurship and growth: the strategic use of external resources. *Journal of Business Ventureing, 4*(2): 133-147.
Jeacle, I. (2004). Emporium of glamour and sanctum of scientific management: The early twentieth century department store. *Management Decision, 42*(9): 1162-1177.
Kidwell, R. & Nygaard, A. (2011). A strategic deviance perspective on the franchise form of organizing. *Entrepreneurship Theory and Practice, 35*(3): 467-482.
Kon, Y. & Storey, D.J. (2003). A theory of discouraged borrowers. *Small Business*

Economics, 21(1): 37.

Lahm, R.J. (2005). Bootstrapping: methods entrepreneurs really use to start a business; a holistic view. Retrieved July 12, 2010, From, http://entrepreneurshipclearinghouse.com/sbi2005download/SBI2005-Presentation-Lahm.pdf.

Lahm, R.J. & Little, H.T. (2005). Bootstrapping business start-ups: entrepreneurship literature, textbooks, and teaching versus current business practices? *Proceedings of the Academy of Entrepreneurship, 11*(2): 15-19.

Lee, J. & Venkataraman, S. (2006). Aspirations, market offerings, and the pursuit of entrepreneurial opportunities. *Journal of Business Venturing, 21*: 107-123.

Lévi-Strauss, C. (1966). *The savage mind.* Chicago, IL: University of Chicago Press.

Litz, R. & Stewart, A. (2000). Research note: Trade name franchise membership as a human resource management strategy: Does buying group training deliver 'true value' for small retailers? *Entrepreneurship Theory and Practice, 25*(1): 125-135.

Locke, E. A. (1978). The ubiquity of the technique of goal setting in theories of and approaches to employee motivation. *Academy of Management Review, 3*: 594-601.

Locke, E. A. (1982). The ideas of Frederick W. Taylor: An evaluation. *Academy of Management Review, 7*: 14–24.

Locke, E. A., Shaw, K. N., Saari, L. M. & Latham, G. P. (1981). Goal setting and task performance: 1969-1980. *Psychological Bulletin, 90*: 125-152.

Mamis, R.A. (1992). The secrets of bootstrapping: 18 ways to grow or survive by substituting imagination, know-how, or effort for capital. *Inc*. Retrieved July, 2010 from http;//www.inc.om/magazine/19920901/4287.html.

McDougal, P.P. & Oviatt, B.M. (2000) & Oviatt, B. M. (2000). International Entrepreneurship: the intersection of two research paths. *Academy of Management Journal, 43* (5): 902-906.

Mohanty, R.P. (1993). Revisiting scientific management. *Work Study, 42*(6): 10-12.

Moorman, C. & Miner, A.S. (1998). Organizational improvisation and organizational memory. *Academy of Management Review, 23*: 698-723.

Orlikowski, W. J. (1996). Improvising organizational transformation over time: A situatedchange perspective. *Information Systems Research, 7*(1): 63–92.

Orlikowski, W.J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*: 404–428.

Pfeffer, J. & Salancik, G. (1978). The external control of organizations. New York, NY. Harper & Row.

Quadrini, V. (1999). The importance of entrepreneurship for wealth concentration and mobility. *The Review of Income and Wealth, 45*(1): 1-19.

Richardson, B. (1995). How to manage your organization scientifically. *The TQM Magazine, 7*(4): 42.

Roberts, B. (2003). Bootstrapping is back: entrepreneurs dig deep and make personal sacrifices for their businesses. *Electronic Business, 29*(4): 44-45.

Sayles, L. & Stewart, A. (1995). Belated recognition for work flow entpreneurs: A case of selective perception and amnesia in management thought. *Entrepreneurship Theory and Practice, 19*(3): 7-24.

Schachter, H.L. (2010). The role played by Frederick Taylor in the rise of the academic management fields. *Journal of Management History, 16*(4): 437-448.

Schumpeter, J.A. (1986/1950). The process of creative destruction. In Barney, J.B. & Ouchi, W.G. (Eds.) *Organizational Economics*. Jossey Bass Publishers: 408-413.

Short, J. C., Ketchen, D. J., Shook, C. L. & Ireland, R. D. (2010). The concept of "opportunity" in entrepreneurship research: Past accomplishments and future challenges. *Journal of Management, 36*(1): 40-65.

Simha, A. & Lemak, D. (2010). The value of original source readings in management education: The case of Frederick Winslow Taylor. *Journal of Management History. 16*(2): 233.

Simon, H.A. (1997). Administrative behavior (4th ed). New York, NY: Free Press.

Simon, D.G. & Hitt, M.A. (2003). Managing resources: Linking unique resources, management, and wealth creation in family firms. *Entrepreneurship Theory and Practice, 27*(4): 339.

Stinchcombe, A. (1965). Organizations and social structure. In March, J.G. (Eds.), *Handbook of Organizations*. Chicago, IL: Rand-McNally.

Sundbo, J. (1999). Empowerment of employees in small and medium-sized service firms. *Employee Relations, 21*(2): 105.

Taylor, F.W. (1903). "Shop management," reprinted in Taylor, F. W. (Ed.) *Scientific Management*. London: Harper & Row.

Taylor, F. W. (1911). *The principles of scientific management*. New York: Harper Brothers.

Teece, D., Pisano, G. & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7): 509-533.

Timmons, J.A. (1999). New Venture Creation: Entrepreneurship for the twenty-first century. (5th ed). New York, NY: McGraw Hill.

Van Auken, H. (2005). Differences in the usage of bootstrap financing among technology-based versus nontechnology-based firms, *Journal of Small Business Management, 43*(1): 93 – 103.

Voss, K., Frankwick, G. & Chakraborty, G. (2002). The maketing- human resource interface: Superior performance for the small business. J*ournal of Business and Entrepreneurship, 14*(2): 69-0_13.

Wagner-Tsukamoto, S.A. (2007). "An institutional economic reconstruction of Scientific Management: on the lost theoretical logic of Taylorism." *Academy of Management Review, 32*: 105-17.

Wagner-Tsukamoto, S.A. (2008). Scientific management revisited: Did Taylorism fail because of a too positive image of human nature? *Journal of Management History, 14*(4): 348-372.

Wennberg, K., Wiklund, J., DeTienne, D. R. & Cardon, M. S. (2010). Reconceptualizing entrepreneurial exit: Divergent exit routes and their drivers. *Journal of Business Venturing, 25*(4): 361-375.

Weick, K. E. (1993). The collapse of sensemaking in organizations: The Mann Gulch disaster. *Administrative Science Quarterly, 38*: 628–652.

Weick, K. E. (1998). Introductory essay: Improvisation as a mindset for organizational analysis. *Organization Science, 9*: 543–555.

Weick, K. E. (2001). Organizational redesign as improvisation. Reprinted in *Making sense of the organization*. Boston: Blackwell.

Winborg, J. & Landstrom, H. (1997). Financial bootstrapping in small business: a resource-based view of small business finance. Paper presented at the Babson-Kauffman Entrepreneurship Research Conference, Babson College, Wellesley, MA, April.

Winborg, J. & Landstrom, H. (2001). Financial bootstrapping in small businesses: examining small business managers' resource acquisition behaviors. *Journal of Business Venturing, 16*(3): 235 – 254.

Wrege, C.D. & Greenwood, R.G. (1991). *Frederick W. Taylor: The Father of Scientific Management, Myth and Reality*, Irwin, IL.

Wren, D.A. (1994). *The evolution of management thought.* New York: John Wiley & Sons Inc.

Wu, L., Wang, C., Chen, C. & Pan, L. (2008). Internal resources, external network, and competitiveness during the growth stage: A study of Taiwanese hight-tech ventures. *Entrepreneurship Theory and Practice, 31*(3): 529.

Zimmerer, T. W., Scarborough, N. M. & Wilson, D. (2008). *Essentials of entrepreneurship and small business management, 6th edition*. Upper Saddle River: Prentice Hall.

Frederick W. Taylor's Presence in 21st Century Management Accounting Systems and Work Process Theories

Marie G. Kulesza
Saint Joseph College

Pamela Q. Weaver
University of Hartford

Sheldon Friedman
Saint Joseph College

Frederick W. Taylor changed the way management looked at manufacturing by using a scientific methodology to study workers' motions, thus developing the foundation for management accounting. Modern management accounting systems such as standard costing, activity-based costing, theory of constraints, and lean manufacturing reflect numerous lessons learned from the Taylor era. This paper contains a review of the connections between Taylor's theories and modern management accounting systems. As management accounting systems evolve in the 21st century, some theorists predict a return to aspects of Taylorism, as adapted to accommodate the modern knowledgeable worker and highly mechanized production systems.

Discussions often revolve around Frederick W. Taylor's study of the movement of workers and this effort to maximize productivity. Taylor described this study as *task analysis* or *task management*, which later became known as *scientific management* (Drucker, 1999b). The use of a stopwatch to study the motions of production workers allowed Taylor to design a series of movements that promoted efficiency. In addition, the results of these studies drew attention to the importance of accurate measurement of resources consumed and standardization of workflows for effective management decision-making and control. While Taylor measured activities in terms of time, he also brought awareness to the fact that managing resources was not only about physical resources, but included intangible resources and processes (Verico & Williams, 2005).

Taylor's method of using a stopwatch and designing physical labor, thus standardizing the labor processes, provided a link with modern day management accounting and management control systems. The literature contains few articles written in the 21st century about the influence of Taylor on modern day management accounting systems. However, the modern approaches reflect numerous lessons learned from the Taylor era. In particular, standard costing, activity-based costing, theory of constraints, and lean manufacturing in the United States bear imprints of Taylor's work.

The first section of the paper considers the early development of management accounting methods and Taylor's contribution in facilitating the advancement of cost systems, standardized costing, and efficiencies in production processes. The second section provides evidence of Taylor's impact on lean manufacturing in the United States. The third section reflects upon the outlook of management accounting systems as the 21st century begins and the steadfastness of Frederick W. Taylor's theories and his scientific management methods.

The Development of Management Accounting

Management accounting was first defined as "...the process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication of financial information used by management to plan, evaluate, and control an organization and to assure appropriate use of and accountability for its resources" (Institute of Management Accountants, 2008, p.1). Through the analysis of the historical development of management accounting, theorists could mark out methods and theories in support of this definition. Frederick W. Taylor's work was a core element to these developments as seen in his efforts to analyze processes, establish standards, create variance analysis, and measure and allocate overhead (Kanigel, 1997).

A formalized system of management accounting emerged during the industrial revolution in the textile, and iron and steel industries. Firms operating in these sectors used management accounting to monitor costs based on output from raw materials to finished product. Managers were concerned with controlling resources consumed in production, in particular, direct labor. During this era, prevailing market prices dictated the cost of labor, thus managers were compelled to control the rate of productivity by workers and used management accounting information to do so (Johnson & Kaplan, 1987). Comparisons of a worker's performance to other workers performing the same process over a period provided analysis for evaluation. All cost information provided by these comparisons aided management's evaluation of internal processes and encouraged workers to achieve company productivity goals (Johnson & Kaplan, 1987).

Later on, the complexity of operations and widespread geographical locations of organizations in the railroad industry led to the establishment of more detailed management accounting systems than had been utilized by manufacturing firms to date. Elaborate calculations generated from the management accounting system measured the cost per ton-mile for efficiency. The calculations allowed comparisons of several operating components including the evaluation of maintenance and overhead (Wren, 1994). The increasing volume of transactions warranted the need for a more sophisticated approach to systemizing the transactions. Managers divided operations into specialized processes or subunits (Johnson & Kaplan, 1987). Summary reports related the operating statistics for each specialized process or subunit for evaluation and control by management. Railroad operations such as Louisville & Nashville were the first to assign divisions of management to oversee subordinate managers of specialized processes (Johnson & Kaplan, 1987).

As manufacturing firms progressed to more complex and larger operations, internal procedures to coordinate the multitude of processes were essential. Andrew Carnegie expanded the existing cost accounting system to accommodate the needs of mass production. The development of a voucher system used by the railroad became an integral part of the cost accounting system. Each department listed the amount and cost of materials and labor used on each order as it passed through the subunit on cost sheets (Johnson & Kaplan, 1987). The primary function of the cost sheets was to accumulate the direct labor cost and material usage. Management used these sheets as an instrument for control. Carnegie proposed that the additional effort involved in paying attention to costs resulted in increased profits (Johnson & Kaplan, 1987).

Advancements Lead to Scientific Management and Efficiency

The demand for more precise information regarding efficiency of workers became paramount in the view of management as mass production dominated the market. The labor structure was based on a contractual system in which underperformance was a prominent practice. Under this system, management provided facilities, machinery, raw materials, and selling channels, while contracted supervisors supplied the labor (Johnson & Kaplan, 1987). The income of the contracted supervisor was the difference between the wages paid to the laborers and sales to management, plus the day's pay received as an employee (Johnson & Kaplan, 1987). Management benefited from lower costs and the relief of responsibility of control of laborers, but they were unable to direct the productivity levels (Johnson & Kaplan, 1987).

The contracted supervisors or the workers themselves dictated the labor steps and process. On the job training from previous employees or from the contracted supervisors was the standard. The efficiency of the process employed was of little concern to the workers, as productivity level had little impact on compensation. Teams of engineers began intensive efforts to establish standards by which the manufacturing firms achieved optimal productivity through efficient use of resources. Frederick W. Taylor and the advent of scientific management were major contributors to this goal. Many manufacturing firms began to break down the contractual labor structure and build systems to track resources consumed during production (Johnson & Kaplan, 1987).

During his association with the Manufacturing Investment Company as a consulting engineer, Taylor immersed himself into the world of accounting and began to customize accounting systems to suit his clients (Kanigel, 1997). Taylor's systems provided detailed monthly statements of expenses by job along with time studies, piece rates, and standardization (Verico & Williams, 2005). Relying on the production planning system at Midvale, Taylor developed a cost accounting system that set up expense classifications, distributed overhead expenses, and improved materials handling and control systems (Wren, 1994).

Measurement and allocation of overhead costs became a significant focus of Taylor's work. In the industrial era, where labor and machine tools dominated production costs, the allocation of overhead costs was prorated based on time to produce. Taylor realized that other activities were utilizing resources and thus apportioned those resources as part of the cost of operations. Taylor's accounting system classified planning, industrial engineering, training, and tool management as overhead (Vercio & Williams, 2005).

In his book *Shop Management*, Taylor (1911a) outlined in detail the various departments manufacturing organizations should employ and their respective functions. One superintendent could manage the entire factory operations by strategically locating vital departments adjacent to production, in particular, the planning department (Taylor, 1911a). No longer would the factory perform operations under a rule-of-thumb method imposed by managers, but instead were planned and controlled in a very systematic fashion by the planning department.

The main responsibilities of the planning department included (a) the complete analysis of all orders for work, (b) time studies for all work by hand and all operations by machine, (c) inventory control, (d) establishing standards, (e) determining costs of all items manufactured, and (f) monitoring and setting improvements for the production line, as well as various administrative functions related to the operations (Taylor, 1911a). By placing the cost accounting function in the planning department, the accumulation and synchronization of all costs of production were reconciled with daily operations reports. Costs then became an integral part of daily planning and control, rather than a subject for analysis after a long passage of time (Wren, 1994). Taylor recognized that accounting information was vital to successful operations and effective management.

Contemporary Trends Trigger Innovative Practices

The manufacturing environment faced dramatic changes in the late 1970's due in part to severe economic problems in the United States. Facing strong global competition and emerging innovative technology, manufacturing firms had to realign their strategies. "The practice of focusing on direct-labor performance and overhead rates is gradually being replaced by throughput, machine utilization, quality, vendor performance, inventory level, and delivery-performance measures" (Seed, 1988, p.8). In addition, an inventory management approach receiving a significant amount of attention was just-in-time (JIT). Under this approach, often referred to as lean manufacturing, companies reorganized factories to manage and eliminate waste.

As product lines increased and markets expanded globally, the need for a more sophisticated system of tracking and allocating costs to production was essential. The advancements in information technology allowed managers access to critical cost data more quickly than in Taylor's era. As a result, managers saw the benefit of scientific management theories as a vital management tool for control and for decision-making. This fundamental association of resources to activities recognized by Taylor came into sharper view with the development of activity-based costing (ABC) systems.

In the early 1980's, manufacturing operations began to evolve into processes that were more complex. Labor costs represented a smaller percentage of production costs than was seen in decades prior (Albright & Lam, 2006). This evolution made the traditional method of allocating overhead costs based on volume (direct labor hours or machine hours) archaic because it resulted in imprecise product costs. Management recognized the compelling need to change approaches and once again turned to Taylor.

In his book *Shop Management*, Taylor (1911a) emphasized task analysis and managerial control of the whole production process. Taylor outlined a succession of tasks or *activities* carried out in each department to heighten individual work efficiencies and productivity. The major focus was on direct labor as the main activity. The evolution of automated production directed management's attention to all activities involved in production, not just direct labor. Management once again drew on scientific methodologies to study and analyze all activities directly involved in and supporting the production process.

An ABC system characterizes an activity as a process or operation performed in the production cycle. The activity may involve preproduction tasks, such as material procurement or product reengineering, as well as actual production tasks. The ABC system captures the cost of these activities whether it is labor, material, or factory overheard consumed by products and assigns those costs in proportion to activities consumed (Albright & Lam, 2006). This assignment of cost was a major advancement in management accounting by providing relevant financial data for cost control and process redesign.

ABC methods consider that overhead costs may not only arise as units are produced, but by varying production processes. "The ABC process is able to incorporate both physical measures and causal principles in the costing system" (Popesko, 2010, p. 103). The three main elements of ABC are (a) identification of the activities in the production processes, (b) determination of the costs related to the identified activities, and (c) assignment of activity costs through *cost drivers* (Tardivo & Di Montezemolo, 2009). An analysis of identified activities provides a measurement of the related costs or resources consumed in the performance of the activity. Once the costs are associated with an activity, an appropriate allocation of these costs is applied to production and then to the finished product. The application of costs on a cause and effect relationship provides the basis for allocation of costs.

Identification of cost drivers or activities closely correlated with the incurrence of costs within a process or operation is a key component of ABC. This approach of cost analysis eliminates the distortion of allocated overhead as seen under traditional costing systems (Albright & Lam, 2006). Using more reliable information, management is able to implement appropriate efficiency measures to improve production. Understanding processes and managing the flow of resources under ABC is a manifestation of the ideas in scientific management reflective of the current manufacturing environment.

Process Improvement Strategies

To supplement the ABC system, management often employs additional process improvement strategies. The theory of constraints (TOC) and material requirement planning (MRP) are process improvement strategies that emphasize throughput as a means of maximizing efficiency and the flow of value through the system. A thorough understanding of the entire production process and managing inventory flow are the underlining aspects to TOC. The function of MRP is to determine the quantity and time of the release of inventory into production to ensure a continuous flow (Kumar & Suresh, 2008). To achieve optimal efficiency through continuous improvement, management should apply a measure of synchronization to these strategies. The flow of value through the system is therefore a measure of lead-time from system input to system output (Anderson, 2004).

The TOC draws from Taylor's mechanisms to identify and quantify the constraints impeding the production process. Where Taylor focused on time and motion studies of individual workers, TOC studies processes as a whole to identify inefficiencies. The basic tenet applied under TOC, as in Taylor's scientific management, is that of establishing the best possible production flow and increasing profits (Albright & Lam, 2006).

To achieve greater throughput levels, management had to begin thinking about the impact of constraints on efficiencies, productivities, and setups (Reimer, 1991). In place of stopwatches and slide rules, industrial engineers used information technology to develop models that simulated production flow (Albright & Lam, 2006). Applying scientific methods, management was able to identify constraints and guide production scheduling to minimize delays. Time, not labor, is the critical aspect of TOC. The scheduling of inventory into and through production was integral to production efficiency.

Inventory management is an element of production that Taylor appreciated and incorporated in his design as a means of timing and controlling the cost of manufacturing. "MRP is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements" (Kumar & Suresh, 2008, p.133). Under TOC, the release of inventory is in accordance with the constraint. MRP technique exploits this dependent relationship to avoid excess build up of inventory (Kumar & Suresh, 2008).

In the era of mass production, Taylor's development of production standards and work efficiency studies were instrumental in changing management accounting systems and work processes. As production shifted towards lean manufacturing, advancements in technology expanded management's capability for detailed analysis regarding the flow of production in an effort to eliminate waste. The development of more refined costing systems provided more accurate cost data on which to base management decisions. Globalization, decreased product life cycles, and compressed lead-time required a shift in management accounting systems and work processes.

Lead into Lean Manufacturing

Taylor developed cost systems to monitor production, measure labor and material efficiencies, and to link data to profits. Taylor's standard cost methods, material and handling controls, floor shop layout, and creation of management departments enhanced cost accounting systems. The flow of cost data and centralized information points improved management's ability to design production processes, set productivity levels, and address bottlenecks in the process.

The later part of the 20th century experienced extreme changes in the manufacturing environment. Technological advancements, improvements in engineering, and global competition led to shifts in business operations. No longer were companies mass-producing standard products, but rather customizing products to a mass market. With product life cycles decreasing and the rapid demand for products increasing, the need for strong communication across operations and the need for more reliable cost information became crucial. Businesses saw the need to develop and implement accounting methods and work processes to contend with the realities of this changing market place.

Taylor's Influence on Lean Manufacturing in the United States

A review of management accounting concepts would be incomplete without a discussion of lean manufacturing. Lean manufacturing involves the elimination of waste throughout the value chain. Waste, also known by the Japanese term *muda*, is "any human activity which absorbs resources but creates no *value*" (Womack & Jones, 2003, p. 15). In studying the practices followed by companies implementing lean manufacturing in the United States, several represent a logical evolution of various aspects of Taylor's theories. In particular, Taylor's work on time and motion studies, as well as his focus on the worker, appears to have formed the basis of several lean manufacturing principles employed years later.

Taylor (1911b, p. 5) began the introduction of his book, *The Principles of Scientific Management*, with the following quote from President Roosevelt regarding the societal concern about waste: "The conservation of our national resources is only preliminary to the larger question of national efficiency." Taylor (1911b, p. 5) discussed the concept of waste of both material things and the "awkward, inefficient, or ill-directed movements of men." Although Taylor's theory of scientific management and lean manufacturing employ markedly different approaches, the elimination of waste through improved worker efficiency was the underlying theme of both theories.

Time and Motion Studies and Changes to Compensation Structure

The manufacturing environment in the late 1800's and early 1900's was plagued with a variety of problems related to efficient worker production and resource management. Taylor began to study worker movements and the most efficient use of equipment and materials using a scientific methodology (Wren, 1994). Taylor's objective was the maximization of profitability for both the company and the employees (Taylor, 1911b). Rather than requiring a group of extraordinary employees to meet this goal, Taylor (1911b) postulated that a systematic approach to management using detailed instructions for the employees would allow ordinary employees to achieve maximum performance.

The empirical study of job activities led to the development of performance standards for each job (Wren, 1994). Once the standards were in place, management had to take a more active role in employee supervision and the development of an appropriate compensation system (Taylor, 1911a; Wren, 1994). Taylor proposed a dual compensation system. Workers who were not able to meet the standard earned a lower rate of pay, while those workers who made the effort to meet the standard received higher compensation (Taylor, 1911a; Wren, 1994). Taylor (1911b) proposed the concept of the *first-class man* to describe the person who was capable and able to produce at the highest level. To maximize the performance of the first-class man, management had to match the capabilities of the worker with the requirements of the job (Wren, 1994). Taylor advocated the concept of the *functional foreman*, where a worker had authority over a task or series of tasks because of the foreman's knowledge about the task rather than authority based on the foreman's position within the organization (Wren, 1994). Many of these concepts continue for companies implementing lean manufacturing.

The Essence of Lean Manufacturing in the United States

The concepts of lean manufacturing began at the Toyota Motor Corporation in Japan as early as the 1950s, in response to concerns about scarce resources and competition in the Japanese automobile market (Hines et al., 2004). In the 1970s, Toyota representatives began to share the concepts with companies outside of Japan (Hines et al., 2004). Intrigued by the superior performance of Toyota, western manufacturing companies introduced modified shop floor aspects of lean manufacturing, while ignoring many of the human elements relating to organizational culture (Hines et al., 2004).

The shop floor or structural aspects of lean manufacturing include the just-in-time production system, the *kaban* method of pull production, and employee problem-solving (Hines et al., 2004). Just-in-time production involves organizing the shop floor so that the product flows quickly and efficiently through the processes, as opposed to the traditional batch and queue models (Womack & Jones, 2003). Workers produce product quickly and in response to customer orders, eliminate the need for inventory (Womack & Jones, 2003). In pull production, the manufacturing of a product begins only when a customer orders it and involves all the downstream steps required to deliver the product to the customer (Womack & Jones, 2003). Trained and cross-trained employees are responsible for solving problems and empowered to stop production to solve mistakes (Womack & Jones, 2003). The desired outcome of all three aspects is the reduction of waste, and thus the reduction of costs (Hines et al., 2004).

In 1983, General Motors and Toyota announced a joint venture called New United Motor Manufacturing Inc. (NUMMI) as a successor to the General Motors plant in Fremont, California. NUMMI represented a theoretical example of lean manufacturing in the United States. The management at NUMMI used a time and motion concept based on Taylor's principles with a goal of superior productivity and quality combined with increased worker motivation and satisfaction (Alder, 1993). Unlike Taylor's concept of time and motion analysis performed and controlled by management, workers at NUMMI learned how to analyze the work and achieve continuous improvement in both process and quality (Alder, 1993). NUMMI is a good example of adapting Taylor's theory to reflect the changing times and avoiding some of the negative effects Taylor experienced, such as resentment from the workers.

Levin (2006) argued that worker participation in meaningful decision-making and sharing of benefits led to higher worker productivity. As an example, Levin (2006) cited the NUMMI plant and its practice of employing teams of five to eight workers who determined their work task assignments and discussed how to improve both products and processes. The teams solved their own problems and workers were significantly involved in the work management (Levin, 2006). Workers also had input into balancing workload and establishing job rotation schedules to reduce worker strain (Strauss, 2006). The productivity in the NUMMI plant was 50% higher than the plant achieved under previous GM management, absences were significantly reduced, and quality was improved (Levin, 2006).

In a study regarding the successful management of resource use, waste, and environmental pollution, Rothenberg (2003) found that worker involvement at the NUMMI plant created an atmosphere of improved knowledge and responsibility regarding pollution issues. Strauss (2006) concluded that management was more likely to adopt worker participation structures when management believed such structures would benefit the company. For companies like NUMMI who were striving for high levels of production, the focus on worker participation and empowerment appears to have helped the company reach its goals.

The Relationship Between Taylor and Lean Manufacturing

Taichi Ohno, creator of Toyota's production system, credits Henry Ford as the originator of the concept of lean manufacturing (Peterson, 2002). One of Ford's subordinates, Ernest Kanzler, played a major role in developing just-in-time production methods (Peterson 2002). Ford's assembly line method used quality parts and proper assembly, with an emphasis on continuous improvement (Peterson, 2002). Ford also emphasized efficiency along the value chain by using local component shops to minimize transportation (Peterson, 2002).

Peterson (2002) noted that although there is no evidence of a direct relationship between Ford and Taylor, Ford's subordinates were well versed in Taylor's philosophy, and both men were aware of each other's approaches. Peterson (2002) concluded that Ford developed his methods on his own in response to the unique needs presented by the automobile industry. The fact that the leaders at Toyota turned to Ford for advice was logical given Ford's success in the auto industry.

Although the debate continued of whether Taylor influenced the origins of lean manufacturing at the Toyota plant in Japan, there is ample reflection of Taylor's theories in the evolution of lean manufacturing in the United States. Rather than simply a production technique, lean manufacturing was a pervasive philosophy focused on eliminating waste in the manufacturing process (Parks, 2003). Workers in a company using lean manufacturing relied on specific instructions for standardized work methods (Parks, 2003). The standardized work methods used engineering techniques promoting efficiency and reducing waste similar to those developed by Taylor (Parks, 2003). Parks (2003, p. 42) concluded "...lean manufacturing is a natural extension of the classical industrial engineering tools such as plant design and layout, workplace design, methods analysis, and time study".

Waddell (2005) expanded the concept of the relationship between Taylor and lean manufacturing by suggesting that lean manufacturing took Taylor's principle of scientific management as it related to labor and extended the principle to the entire factory. Workers searched for waste in any aspect of production, including indirect costs (Waddell, 2005). Ultimately, in lean manufacturing, workers optimized direct labor and minimized manufacturing support costs (Waddell, 2005).

From the perspective of operations management, Voss (1995) drew a direct connection between Taylor's work regarding the development of mass production processes and lean manufacturing. Critical to lean manufacturing and the reduction of batch sizes are the single minute exchange of dies (SMED) developed using industrial engineering concepts stemming from Taylor's concepts (Voss, 1995). Additionally, Taylor's focus on the organizational aspect of the factory and the role of the individual has been a key element in the development of lean manufacturing (Voss, 1995). As lean manufacturing evolves in the future, Taylorism will continue to be an important aspect of lean manufacturing theory.

An Extension of Taylorism into the 21st Century

Just as Taylor dissected each manufacturing process into its component parts for modification, improvement, or elimination to promote efficiency (Gabor, 2000), managers in the 21st century must have thorough knowledge of all activities in the production process including automated activities. Advances in information technology systems afford managers a comprehensive series of methods to gather and analyze data in order to institute timely changes in the production flow. In the competitive environment of the 21st century, the ability to respond quickly to constraints is essential to sustaining the economic viability of the company.

Effectiveness and Efficiency in the 21st Century

Activity-based costing, theory of constraint, and material requirement planning arose as a reflection of the current manufacturing environment and the advent of advanced information technology. Each provides management with tools to monitor production flow, control costs, evaluate performance, measure outcomes, and ensure efficiency in operations. The successful employment of these tools requires management to have a complete understanding of all activities in the production process, which in turn, enables effective management of the process.

With the pressures of global competition, the demand for high quality products, and timely delivery expected by customers, Taylor's theories continue to have relevance. However, with a greater reliance on artificial intelligence, the mechanism by which managers obtain and analyze relevant information will continue to change (Seed, 1988). Due to the automation of production process and process control systems, managers have more timely access to accurate cost information (Seed, 1988). The modernization of Taylor's methods provides a more predictable throughput allowing efficiency in process performance with minimal waste (Seed, 1988). The progression from stopwatches to information technology when gauging efficiency has modernized Taylor's original theory of scientific management.

Corporate Sustainability and Reverse Logistics

The focus on waste reduction in the manufacturing process evolved into the corporate sustainability aspect of corporate social responsibility. Beginning in the late 20th and early 21st century, companies began to consider the environmental impact of corporate actions on present and future generations (Aras & Crowther, 2008). As part of the application of social responsibility, companies began to monitor the usage of scarce resources (Aras & Crowther, 2008).

In its simplest form, sustainability limits the use of a resource to an amount that can be adequately regenerated (Aras & Crowther, 2008). In a global economy, the concept of corporate sustainability places the company within a broad social and economic system where the company must attempt to balance economic growth and environmental protection on a global basis (Aras & Crowther, 2008). The quantification of the resultant social, environmental, economic, and ecological costs requires new or adapted systems of managerial accounting to provide decision-makers with needed information (Schaltegger & Burritt, 2006). In addition to external sustainability reporting to communicate the general management strategy regarding sustainability, a bottom-up, decision-focused model can help the company reduce costs and increase competitiveness by incorporating sustainability concepts throughout the organization (Joshi & Krishnam, 2010).

Additionally, in the late 20th century, companies began to examine the notion of reverse logistics, which, in addition to the return and disposal of unwanted products, included the recycling of packaging materials (Schwartz, 2000). Traditionally, the market or the shipper's requirements dictated the packaging design without regard to disposal (Chan, 2007). Concern for the environment, as well as sustainability, resulted in the development of returnable and reusable packaging to both save costs and environmental resources (Chan, 2007).

A Possible Return to Modified Taylorism

Vidal (2004) proposed that the increased stress on the workers due to making decisions and taking responsibility might result in a return to traditional Taylorism. Workers who had job security and acceptable wages, especially those working in companies where the empowerment was not significant, often became disenchanted with lean manufacturing methods (Vidal, 2007). Vidal (2007) also found that workers motivated by a broad range of factors were satisfied when working under traditional methods. Some companies began to employ a variety of structures ranging from traditional batch and queue methods to a lean cellular model in an effort to improve worker satisfaction and performance.

In his review of management through history and projection into the 21st century, Drucker (1999b) reported that in the late 20th century, a focus on teams replaced the top down structure of Taylor's theory. For the 21st century, Drucker (1999b) advocated a new focus on the leader, not to manage people as Taylor conceived, but rather to lead people to maximize their productivity. This maximization of productivity required obtaining and applying significant technical knowledge when performing manual tasks (Drucker, 1999b). Unlike the untrained worker from Taylor's time who depended upon the technical skills of management, the knowledge worker applied their own learned skills when performing tasks (Drucker, 1999b).

The maximization of productivity required workers to employ knowledge rather than simply working hard and efficiently (Helper, 2009). Strict standardized procedures, such as those employed by Taylor, stifled the creativity needed for continuous improvement and learning (Alder, 1993). The achievement of high productivity or productive output in the 21st century may require management to continue to focus on standards and efficiency, while also learning important lessons from the NUMMI plant in regards to adapting Taylor's methods to involve the workers in the process. Continuous improvement, so vital to the modern manufacturing process, requires workers to manage themselves and take responsibility for learning new skills (Drucker, 1999b).

Conclusion

Work process theories and management accounting methods often change as the economy, manufacturing processes, and other social dynamics change. Traditional Taylorism, as proposed by Taylor in 1911, may not exist in the modern manufacturing climate, but multiple aspects of Taylor's theories and practices continue to have relevance. New methods and theories will continue to evolve from the lessons learned throughout history.

Taylor (1911b, p. 140) concluded his book *The Principles of Scientific Management* with the following passage:

> It is no single element, but rather this whole combination, that constitutes scientific management, which may be summarized as: Science, not rule of thumb. Harmony, not discord. Cooperation, not individualism. Maximum output, in place of restricted output. The development of each man to his greatest efficiency and prosperity.

These words continue to guide operations management and the related management accounting systems today.

The globalization of the world's economies, the rapid change in technology, and the demands of an increasingly complex world continue to challenge our manufacturing processes. Today, more than ever, companies are increasingly reliant on knowledge workers (Drucker, 1999a; Drucker, 1999b). However, while maximizing manual worker productivity continues to have an important role in the growth of developing countries, knowledge worker productivity in developed countries has expanded to non-manufacturing industries such as medicine, education, and research (Drucker, 1999a). Because the tasks completed by the workers from non-manufacturing industries often involve both knowledge work and manual labor, the ability to attract and motivate high producing workers through sound management can result in improved performance for the organization (Drucker, 1999a).

The workers of the 21st century are better educated and rely on more mechanized systems than in Taylor's time. These developments allow management to fine tune production processes in the search for greater efficiency and productivity. In June 2008, the Institute of Management Accountants presented the following new definition of management accounting: "Management accounting is a profession that involves partnering in management decision making, devising planning and performance management systems, and providing expertise in financial reporting and control to assist management in the formulation and implementation of an organization's strategy" (p. 1). This new definition is an adaptation of Taylor's original theory recognizing the value of the knowledge worker and the worker's contribution to the maximization of the prosperity of the worker.

References

Alder, P. S. (1993). Time-and-motion regained. *Harvard Business Review, 71*(1): 97-108. Doi: 10.1225/93101.

Albright, T. & Lam, M. (2006). Managerial accounting and continuous improvement initiatives: A retrospective and framework. *Journal of Managerial Issues, 18*(2): 157. Retrieved from Academic OneFile (A147748398).

Anderson, D.J. (2004). Management accounting for systems. In Pearson Education, Inc. (Ed.), *Agile management for software engineering: Applying the theory of constraints for business results* (pp. 15-28). Retrieved from http://www.amazon.com/gp/product/images/B003CW67YG/ref=dp_image_0?ie=UTF8&m=AG56TWVU5XWC2&n=133140011&s=digital-text.

Aras, G. & Crowther, D. (2008). Corporate sustainability reporting: A study in disingenuity? *Journal of Business Ethics, 87*: 279-288. Doi: 10.1007/s10551-008-9806-0.

Chan, H. K. (2007). A pro-active and collaborative approach to reverse logistics – a case study. *Production Planning & Control, (18)*4: 350-360. Doi: 10.1080/09537280701318736.

Drucker, P. F. (1999a). Knowledge-worker productivity: The biggest challenge. *California Management Review, 41*(2): 74-94. Retrieved from ABI/Inform Global.

Drucker, P. F. (1999b). Management challenges for the 21st century. New York, NY: HarperCollins.

Gabor, A. (2000). Frederick W. Taylor: The father of scientific management. In *The capitalist philosophers: The geniuses of modern business – Their lives, times, and ideas* (pp. 3-43). New York, NY: Times Business.

Helper, S. (2009). The high road for U.S. manufacturing. *Issues in Science and Technology, 25*(2): 39-45. Retrieved from http://www.issues.org/25.2/helper.html.

Hines, P., Holweg, M. & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management, 24*(10): 994-1011. Doi: 10.1108/01443570410558049.

Institute of Management Accountants. (2008). *Statements on management accounting*. Retrieved from http://imanet.org/pdf/definition.pdf.

Joshi, S. & Krishnan, R. (2010). Sustainability accounting systems with a managerial decision focus. *Cost Management, 26*(6): 20-30. Doi: 2222983661.

Johnson, H.T. & Kaplan, R.S. (1987). Relevance lost. Boston, MA: Harvard Business School Press.

Kanigel, R. (1997). *The one best way: Frederick Winslow Taylor and the enigma of efficiency*. New York, NY: Viking.

Kumar, S.A, & Suresh, N. (2008). *Introduction to production and operations management (with skill development, caselets and cases)*. (2nd ed.). Daryaganj: New Delhi: New Age International Ltd. Publishers. Retrieved from http://www.slideshare.net/erletshaqe/introduction-to-production-and-operation-management.

Levin, H. M. (2006). Worker democracy and worker productivity. *Social Justice Research, 19*(1): 109-121. Doi: 10.1007/s11211-006-0002-z.

Parks, C. M. (2003). The bare necessities of LEAN. *Industrial Engineer: IE, 35*(8): 39–42. Retrieved from http://www.iienet2.org.

Peterson, P. B. (2002). The misplaced origin of just-in-time production methods. *Management Decision, 40*(1/2): 82-88. Doi: 10.1108/00251740210413398.

Popesko, B. (2010). Activity-based costing application methodology for manufacturing industries. *E+M Eknomie a Management, Lieberec, 1*: 103-110. Doi: 1975382801.

Reimer, G. (1991). Material requirements planning and theory of constraints: Can they coexist? A case study. *Production and Inventory Management Journal 32*(4): 48-52. Retrieved from ABI/FORM Global.

Rothenberg, S. (2003). Knowledge content and worker participation in environmental management at NUMMI. *Journal of Management Studies, 40*(7): 1783-1802. Doi: 10.1111/1467-6486.00400.

Schaltegger, S. & Burritt, R. L. (2006). Corporate sustainability accounting: A nightmare or a dream come true? *Business Strategy and the Environment, 15*(5): 293-295. Doi: 10-1002/bse.527.

Schwartz, B. (2000). Reverse logistics strengthens supply chains. *Transportation & Distribution, 41*(5): 95-100.

Seed, A.H. III. (1988). *Adapting management accounting: Practice to an advanced manufacturing environment*. Montvale, NJ: National Association of Accountants.

Strauss, G. (2006). Worker participation – some under-considered issues. Industrial Relations, 45(4): 778-803. Doi: 10.1111/j.1468-232x2006.00451.x.

Tardivo, G. & Di Montezemolo, G.C. (2009). Using activity-based management to achieve excellence. *Journal of Financial Management & Analysis, 22*(1): 67-84. Retrieved from Proquest database (186984621).

Taylor, F. W. (1911a). *Shop management*. New York, NY: Harper & Brothers. Retrieved from http://www.google.com/books.

Taylor, F. W. (1911b). *The principles of scientific management*. New York, NY: Harper & Brothers. Retrieved from http://www.google.com/books.

Vercio, A. & Williams, B. (2005). Three innovations in cost accounting. T*he Journal of Corporate Accounting and Finance, 16*(3): 41-45. Doi: 10.1002/jcaf.20102.

Vidal, M. (2004). *Work organization and worker's experience after Fordism: Manufacturing empowerment? Proceedings from the American Sociological Association Annual Meeting*. San Francisco, CA, 1-24. Retrieved from http://www.allacademic.com/meta/p109500_index.html.

Vidal, M. (2007). Lean production, worker empowerment, and job satisfaction: A qualitative analysis and critique. *Criminal Sociology, 33*: 247-278. Doi: 10.1163/156916307x168656.

Voss, C. A. (1995). Operations management – from Taylor to Toyota – and beyond? *British Journal of Management, 6*: 17-29. Doi: 10.1111/j.1467-8551.1995.tb00135.x.

Waddell, B. (2005, July). Taylor, stopwatches, and lean manufacturing. *Factory Strategies Group, LLC*. Retrieved from www.superfactory.com.

Womack, J. P. & Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation.* New York, NY: Free Press.

Wren, D.A. (1994). *The evolution of management thought* (4th ed.). New York, NY: John Wiley & Sons, Inc.

The Scientific Management of Information Overload

Linda L. Brennan
Mercer University

Examining Frederick Winslow Taylor's seminal work, The Principles of Scientific Management, reveals why many of his ideas were considered controversial. While one might argue against his view of workers' motivation, the principles underlying his efforts towards productivity improvements still apply today. To make a case for the relevance of his contributions for management practice in the 21st century, this article shows first how Taylor's thinking relates to key aspects of lean manufacturing, a popular and contemporary business practice. The coherence of scientific management and lean principles are then further applied to a current and growing problem, information overload, to yield testable propositions for further study. Suggestions for addressing information overload, based on anecdotal evidence, are presented as illustrative.

Many industrial engineers who endeavored to apply manufacturing best practices to professional services firms (Brennan, 2006; Brennan & Orwig , 2000) regularly encountered the types of resistance that Taylor faced: e.g., people are not machines; we have been doing this and know more about how it should be done than you; you are just trying to eliminate jobs, etc.

Taylor's (1911) views of the workers of his day, such as "the workman… is so stupid…" (p. 59), and "almost all tradesmen [are opposed] to making any change in their methods and habits…" (p. 81) have been discredited. However, his methodology did achieve productivity improvements for large industrial concerns, such as The Bethlehem Steel Company. In his extensive biography of Frederick Taylor, Kanigel (1997) gave many examples of the application of scientific management to nonscientific realms, e.g., education, libraries, and home kitchens.

Is this work relevant to management practices in the 21st century? Indeed, it can be asserted that it is quite relevant, in both the manufacturing sector (under the auspices of lean principles) as well as to knowledge work. The following section explains how the principles and practices of scientific management cohere with those of lean manufacturing. Then the specific contemporary issue of the information overload of knowledge workers is considered. By applying lean, scientific thinking to the problem of overload, several propositions are developed.

Management Principles and Practices

The profession of applying science to management was known as scientific management and gradually changed to industrial engineering over the years, becoming formalized in the late 1940's (Emerson & Naehring, 1988, p.119). Kanigel (1997, p. 7) suggested that, "Taylor's thinking… so permeates the soil of modern life we no longer realize it's there… He helped instill in us the fierce, unholy obsession with time, order, productivity and efficiency that marks our age."

While Taylor is renowned for his time studies and work measurement, he did not start out with ideas of efficiency or economy. He was deeply troubled by what he saw as a conflict between labor and equipment. For Taylor, it was a burning social concern (Drucker, 1968). In his own words, Taylor (Taylor, 1911, pp. 9-11) wrote that "the principal object of management should be to secure the maximum prosperity for the employer, coupled with the maximum prosperity for the employé *(sic)". The words 'maximum prosperity' were used, in their broad sense, to mean not only large dividends for the company or owner, but the development of every branch of the business to its highest state of excellence, so that the prosperity might be permanent … the greatest prosperity… can be brought about only when the work … is done with the smallest combined expenditure of human effort…" (Taylor, 1911, pp. 9-11). Work studies and standardized tasks became vehicles for accomplishing this.

Henry Ford was a strong proponent of scientific management and advocated standardizing processes and eliminating waste. He and The Ford Motor Company were the link between Frederick Taylor and Ohno Toyoda, creator of the Toyota Production System (TPS). Ohno read Ford's book, *Today and Tomorrow*, benchmarked the manufacturer's continuous flow assembly line, and began the development of the TPS. Today, principles and practices of the TPS are widely employed in the manufacturing sector under the auspices of "lean production" (Liker, 2005, p. 226).

The concept of "lean" indicates that the proverbial "fat," typically referred to as waste, has been trimmed from the process. Activities in a lean process have the potential to add value. This is true whether describing a manufacturing process, a service process, or even a customer's consumption process.

While the TPS is grounded in manufacturing and based on several broad principles, three can be seen as direct derivatives of scientific management: the need for *direct observation,* the *standardization of tasks*, and *the elimination of waste*. Both Taylor and Ohno advocated the need to really understand the work and observe it closely – and at length. Taylor's studies gathered copious levels of data, task-by-task, second-by-second. Ohno, too, believed in the power of going directly to the source (*genchi genbutsu*) and deep observation. According to Teruyuki Minoura, former president of Toyota Manufacturing in North America, Ohno had him draw a circle on the floor of the plant, stand in it, watch the process, and "think for himself" for eight hours (Liker, 2005, p. 226).

Standardization of tasks was the foundation of continuous improvement, according to the TPS. Similarly, “Perhaps the most prominent single element in modern scientific management is the task idea. This task specifies not only what is to be done but how it is to be done and the exact time allowed for doing it” (Taylor, 1911, p. 39). The conceptualization of standardization at Toyota is broader than it was in Taylor’s time, when it was focused on finding the one best way to do a task and then freezing it. The TPS’ thinking is that “it is impossible to improve any process until it is standardized. One must standardize, thus stabilize the process, before continuous improvements can be made” (Liker, 2005, p. 142).

Often, improvements under lean operations are targeted to eliminate waste in a process, where waste is considered any activity that does not add value, i.e., overproduction, waiting, unnecessary transport, unnecessary processing, excess inventory, unnecessary movement, and defects. In the same way, Taylor emphasized “the enormous saving of time and therefore increase in the output which it is possible to effect through eliminating unnecessary motions…” (Taylor, 1911, p. 24).

Conceptually, these principles applied to all types of work, not just production processes. Taylor saw knowledge, not muscle power, as the prime productive resource, and today the ‘knowledge’ industry is looked to as the source of most new jobs” (Kanigel, 1997, p. 9). Indeed, management guru Peter Drucker acknowledged that the most important step toward a knowledge economy was scientific management (Drucker, 1968).

The question is, are these principles of practical use in a knowledge economy? Certainly, lean principles have been extended beyond manufacturing applications (c.f., Womack & Jones, 2005; Anand & Kodali, 2010; Peterson, 2010). To understand if – and how – they can be applied to one of the greatest challenges for knowledge workers, it is important to understand the problem of information overload.

The Challenge of Information Overload

Overload can be defined as the state of having more than can be handled, whether measured in terms of quantity, weight, rate, or size. Information overload is therefore having more information than one can acquire, process, store, or retrieve. In their comprehensive review of the literature on information overload, Eppler and Mengis (2004, p. 326) offered the following description: “Information overload occurs when the supply exceeds the capacity. Dysfunctional consequences … and a diminished decision quality are the result.”

This is arguably one of the biggest challenges for knowledge workers in this age of technology-driven explosions of information availability. Jaques (1995, p.48) reported on published research from the Economist Intelligence Unit, warning that problems associated with information overload are reaching acute proportions for large enterprises, and that the management of key information sources and intellectual property is spiraling out of control at many companies.

Researchers across various disciplines have found that performance of an individual correlates positively with the amount of information he or she receives, up to a certain point (Eppler & Mengis, 2004). Beyond this point, the individual’s performance will rapidly decline, described by an inverted-u curve (Chewning & Harrell, 1990).

Why is information overloading a challenge? In the knowledge economy, information is presumably people's most valuable commodity (Hemp, 2000, p. 83). However, overload often leads to *stress*, *inefficiency*, and *mistakes* that can result in poor decisions, bad analysis, and/or miscommunication (Eppler & Mengis, 2004).

In 1989, Richard Wurman coined the term "information anxiety," a state of stress caused by an overwhelming flood of data, much of it from computers and much of it unintelligible (Wurman, 2000). More recently, Hemp (2009, p. 84) acknowledged, "The stress of not being able to process information as fast as it arrives… can deplete and demoralize you." Stress can also be caused by concern about not having all of the relevant information needed for a task or project.

Of course, all of the information received is not necessarily relevant. In fact, the Information Overload Research Group (http://iorgforum.org) referred to "information pollution." Shih, Chiang and Lin (2008, p. 117) examined the problem of "spamming… the practice of sending mass mailings to large numbers of people who have no relationship with the seller. As a result, spam was expected to represent 77% of emails sent worldwide by the end of 2009." Hemp (2009, p. 85) reported, "a survey of 2,300 Intel employees revealed that people judge nearly one-third of the messages [of the average of 350 messages/week] they receive to be unnecessary." In fact, one of the leading causes of stress can be the feeling that other people are wasting your time.

In addition to wasted time, information overload can create inefficiencies in several ways. One key way is by multitasking. Another is neglected work due to information addiction, e.g., "Crackberry" users. Accessing the right information at the right time can also be problematic.

Multitasking, processing different information for different tasks at the same time, is a common phenomenon in knowledge work. According to research conducted by Stanford professors Eyal Ophir, Clifford Nass and Anthony Wagner, multitaskers underperformed compared to their non-multitasking peers in three key areas: filtering out irrelevant details, remembering information, and switching between tasks. The researchers attributed this to the multitaskers' distraction of thinking about the task they were not doing and the inability to focus on the task at hand (Ophir et al., 2009). In another study, Crovitzthe (2008) found that, not only did knowledge workers change activities every three minutes with frequent distractions such as an electronic message or a phone call; it then took nearly 30 minutes to get back to the task once attention was lost. A study commissioned by a large high technology company indicated that the IQ scores of knowledge workers distracted by email and phone calls decreased 10 points" (Hemp, 2009, p. 84).

It is no wonder that mistakes can be caused by information overload with the stress and distraction of knowledge workers. Information can be easily overlooked or mistakenly discarded. Some people are so overloaded that they declare email bankruptcy and delete all of their mail (Hemp, 2009). In his efforts to reduce errors in medical practice, Gawande (2009, p. 13) reflected on the situation:

> We have accumulated stupendous know-how…. Nonetheless, that know-how is often unmanageable. Avoidable failures are common and persistent… across

> many fields – from medicine to finance, business to government. And the reason is increasingly evident: the volume and complexity of what we know has exceeded our individual ability to deliver its benefits correctly, safely, or reliably. Knowledge has both saved us and burdened us.

Mistakes may also arise from the incorrect use of information – or from the use of incorrect information.

Stress, inefficiency, and mistakes are not the sole purview of knowledge workers. Scientific management revealed that overload was counterproductive long ago, when Frederick Taylor examined the throughput of the pig iron handlers. He noticed that there were physical limits to the amount men could carry fully loaded, and that "as the load [became] lighter, the percentage of the day under which the man can remain under load [increased]" (Taylor, 1911, p. 57). In other words, by reducing the overload, the men were more productive. In a similar vein, "Ohno considered the fundamental waste to be overproduction, since it causes most of the other wastes" (Liker, 2003, p. 29). Too much could often be less beneficial.

Analysis

With the understanding that overload is problematic, the following analysis examines the problem through a lens common to scientific management and lean principles: the need for direct observation, the standardization of tasks, and the elimination of waste. The question is, how might a synthesis of lean (TPS) and scientific thinking help to address the problem of overload?

Direct Observation

Direct observation, or "go and see for yourself," suggested the need to understand the ways in which the individual knowledge worker processes information. What sources supply information? How is new information received? Filtered? Stored? Accessed? Processed? Discarded?

In addition, it is important to understand the personal factors that can contribute to overload, such as individual traits and personal situational factors (Eppler & Mengis, 2004). For example, the time of day, the amount of noise, or whether the individual felt rested could all make a difference in how much information he or she can process.

Direct observation required an investment of time by the individual to track information sources and processes. While a knowledge worker might not need the stopwatch precision of Taylor, the staying power of Ohno will be required to do this effectively. Observation was, and still is, likely to span days to achieve a clear vision and full understanding.

One approach would be to identify all the roles, personal and professional, in which the knowledge worker used or consumed information. Etzel and Thomas (1996) identified eight key information actions: create, change, store, retrieve, integrate, decide, communicate, and discard. Cross-referencing the roles and the tasks led to the next step, describing the types of information needed for each role, e.g., a social networking group of fathers of teenagers and a school calendar as a parent; company sales data, product information, and competitive analyses as a sales manager; weather reports, and selected blogs as an avid golfer. In this framework, the individual could track the sources and uses of information over a period of time.

For each type of information needed, the overloaded individual could then determine the best sources of information and how often he wanted to or should monitor them. The idea was to define what is important (Etzel & Thomas, 1996). The last step in direct observation would be a gap analysis, determining what information is received but not needed and what is needed but not received, and then addressing the gaps. This should not only lighten the load, but improve the quality of the information use as well.

Standardization

As for the standardization of tasks, several researchers have identified task and process parameters that contributed to information overload (Tushman & Nadler, 1975; Schick, Gorden & Haka, 1990; Bawden, 2001). By establishing routines, simplifying processes, and avoiding interruptions, the overload could shrink. It may take some time to develop the discipline this requires – and it may create some resistance from others – but eventually it would provide relief from overload.

For example, consider a telecommuter, someone who has a home office as well as a traditional office at work. Making a routine weekly schedule that lets coworkers know when she will be working at home eliminates the guesswork and unnecessary communications. It might be possible to simplify things by keeping materials associated with a particular project in one location. This might be stacks of paper in the home office or working files on a computing cloud. This saves the telecommuter from transporting the information and avoids the situation of lost or left behind data. To avoid interruptions, she may impose a discipline of checking mail and messages at certain times, limiting the frequency. Standardization, or in the case of information overload, making the routine as routine as possible, makes sense.

By using the results of direct observation and standardization, there can be many opportunities to reduce the waste created by information overload. This analysis addresses each type of waste, i.e., overproduction, excess inventory, unnecessary transport, unnecessary processing, unnecessary movement, waiting, and defects, and offers empirically-based suggestions for waste reduction.

Types of Waste

Overproduction is producing more than is required, typically by the next process or the customers. This waste is visible in storage needs, which can take time, space, and money. If whatever is produced cannot be used, the disposal process also can have costs (Brue & Howes, 2006).

In terms of information overload, information providers often produce more information than is necessary. Peek (2010) refers to "Social Network Overload" and "Commentary Overload" as two sources of over production. In a business context, the providers may want to maintain a regular line of communication, even if the content is thin, as in the case of weekly or daily "blasts" that may be of little use to the recipients. The proliferation of news outlets has further exacerbated this problem with the pressure to fill empty air space, every hour of every day. In these situations, information is pushed to the recipient. To stem the overload, the individual has some options. One is to employ a "pull" model, only receiving information when it is needed, i.e., "pulled." Another is to impose filters, cognitive or technological, to receive information that is specifically targeted to the individual's interests. In either case, the idea is to improve the individual's screening skills for information (Van Zandt, 2000; Eppler & Mengis, 2004).

Of course, knowledge workers are typically the ones who overproduce. Sometimes, the overproduction is simply thoughtless. Avoid unnecessary email, especially one-word replies such as "Thanks!" or "Great!" (Goldsborough, 2009). One of the most blatant violations is the reflexive "reply all" response in email. To counteract this, Hemp (2009) suggested a "non-cash" stamp daily allotment to each employee, with a feedback system to decrease the allotment of time-wasters. However, that may be more technologically complicated than needed. For example, the website http://five.sentenc.es, suggests establishing a "personal policy that all email responses regardless of recipient or subject will be five sentences or less." An organization may establish a broader policy with rules for information and communication design (Bawden, 2001). Over the long term, the goal would be to have a culture focused on creating value-added information (Simpson & Prusak, 1995).

Excess inventory and *work in process* are also key opportunities for waste, and often occur as a result of overproduction. Lean thinking works on inefficiencies, product complexity, bad scheduling, unreliable deliveries, and poor communications (Brue & Howes, 2006). In the context of information overload, it might be thought of as working on too many things at once.

This can in turn be manifested as multitasking – which, as noted earlier, is extremely inefficient – and can be viewed by the knowledge worker as a habit to break. Another bad habit, and one of the most egregious contributors to an individual's overload, is the tendency to hold on to information "just in case." This excess inventory of information creates an unnecessary layer of complexity in an individual's cognitive workload.

Excess work in process might also take the form of having too many projects open at once. Think of the attorney who has a crushing case load. He essentially becomes the bottleneck in all of these cases, slowing his overall throughput. Each case takes much longer than it should, in overall elapsed time, because of competition for his attention. Frantic scheduling, missed deadlines (i.e., deliveries), and frustrating communications with clients are plausible outcomes.

Excess inventory and work in process for a knowledge worker can be avoided with awareness and self-discipline. Scheduling uninterrupted blocks of time for completing critical work is one positive step (Sorohan, 1994). With the benefit of direct observation and gap analysis, the individual should have a clear idea of what is pertinent and what is not (inventory), and when too many projects and tasks (work in process) constitute overload. This may be an annual exercise to see if and how information needs have changed. Stebbins (2010) advocates scheduling regular "decluttering sessions," which can address physical as well as mental clutter. In addition, by addressing the wastes of overproduction and excess inventory, storage reduction can be achievable.

Transportation, moving anything around during a production process, should be minimized. It generally adds no value for the consumer. Efficient layouts, improved flows, and storage reduction are techniques for eliminating this waste (Brue & Howes, 2006).

For information overload, unnecessary transportation takes the form of paper that is carried to be processed, moved to make room for new information, or pushed aside until it is needed. One way in which layout can mitigate this is with the creation of a "dump zone." Stebbins (2010, p. 153) recommended finding "a space to corral all the stuff you don't have time to put away…Once you're ready to get organized, you won't have to hunt all over…".

From a process standpoint, good in-box management advocates "touching" an inbound piece of information only once: act on it, file it, or discard it (Allen, 2002). Thompson (2006, p. 98) suggests that "for things you need to act on… if you can do it in two minutes, go ahead and do it." If unable to do this, then it can be incorporated into an overall organization system.

A popular lean technique, 5S, stands for "sort, straighten (or set in order), scrub (shine), systematize, and standardize (sustain)" i.e., *seiri, seiton, seisq, seitketsu, and shitsuke* in Japanese (Feld, 2001). The overloaded knowledge worker can benefit by applying 5S particularly to places where information is received and processed, whether at work, the home office, the kitchen, or in a briefcase. This was echoed by Ale Sandrini (1992, p. 80-81): "Turn your desk from a distraction to a work surface by [taking the information and] clean it, leave it for someone else, eliminate it all together, act on it, or read it."

Lean organizations are very neat. Everything has its place, in order to avoid unnecessary transportation and other kinds of waste. Henderson and Larco (1999) asserted, "Most people underestimate the importance of safety, order and cleanliness of the workplace… Toyota and Honda will tell you 25 to 30% of all quality defects are directly related to [these issues]."

Defects and *mistakes* cause waste in several ways. Crosby (1980) identified four costs of quality: prevention, appraisal, and the internal and external costs of defects. Examples of internal costs of defects include scrap and rework, charges related to late payments, inventory costs to allow for some percentage of defect rate, engineering change costs for design correction, premature failure of products, and correcting documentation; external costs of defects can stem from warranty repairs, field service personnel training, complaint handling, customer dissatisfaction, future business losses, and litigation (Ireland, 1991).

These costs apply to defects in knowledge work as well. As noted earlier, errors are often the result of stress and distraction caused by information overload. Eliminating other forms of waste, and thereby reducing at least some of the overload, should logically lead to fewer defects and mistakes.

In addition, to avoid situations where information is overlooked, mistakenly discarded, or incorrectly used, a knowledge worker might use another lean technique known as fail-safes or "*poka yokes*." *Poka yokes* try to prevent errors from occurring. A *poka yoke* can be a warning that signals the existence of a problem, a precautionary measure to prevent a problem from occurring, or a control that stops production until the problem is resolved (Chase, 1994).

For example, overlooking information can be avoided by something as simple as a checklist (Gawande, 2009). Physical *poka yokes* can also be easily implemented, such as placing car keys with meeting materials that might be forgotten in a rush. Technological fail-safes such as data masks, automated backups, and confirmation screens can also be effective prevention measures. Broida (2009) suggested that, to avoid making errors that contribute to others' overload, consider installing a plug-in that alerts the sender to forgotten attachments when sending email.

Unnecessary processing is an obvious source of waste that can be overlooked without a task-by-task evaluation of a process. This situation may be a result of merging operations without streamlining processes. It is also frequently caused by changes in other processes. Another way in which a task may become unnecessary is through technology changes. As sources of information overload, each of these situations can be mitigated in the process of direct observation and gap analysis.

Another source of unnecessary processing, specific to knowledge workers is "tool abuse," i.e., using an information technology inappropriately. The inappropriateness might stem from overuse (witness "Crackberry" addicts and overly elaborate presentation materials) or from incorrect use of a tool. This is particularly evident in computer-mediated communications.

One common phenomenon is "telephone tag," or the exchange of voicemail messages without accomplishing any actual communication. In addition, people overly rely on email, and use it to accomplish tasks for which it is completely ineffective, such as to explain complex procedures, solve complicated problems, and air grievances (Levinson, 2010). Hemp (2009) advocates making suggestions in an email, rather than asking open-ended questions, e.g. when setting up an appointment.

Eliminating unnecessary human motions was a hallmark of scientific management. It reduces cycle time and stress on bodies. Improvements in workplace organization and method consistency can reduce this waste (Brue & Howes, 2006).

Building on the 5S tool, a visual factory adds the element of visual cues and signage. This saves time on storing, search, and retrieval. A knowledge worker might apply this concept using something as basic as labels – on files, drawers, binders, and shelves. In a similar vein, Broida (2009) offers another illustration, using the subject line in email messages to make it a short but informative summary of what is in the body of the email. The idea is for the knowledge worker to visually underscore priorities and view the big picture (Ale Sandrini, 1992).

Waiting is a waste that needs no explanation – but is hard to avoid. To mitigate waiting, an overloaded knowledge worker has two general options. One is to make good use (an individual preference) of the time spent waiting. The other is to address the cause of the wait.

A primary cause of waiting is bottlenecks. A bottleneck is a constraint that limits throughput (Goldratt & Cox, 1994). In knowledge work, the bottleneck may be an overloaded individual or an overloaded process. A chronic problem with a bottleneck should be addressed.

Waiting on an individual may be addressed with follow-up and reminders (euphemisms for nagging). It may be appropriate to set a deadline on a response, e.g., "If I don't hear back from you by next Friday, I will assume the plan is acceptable to you." Proceed with caution, however: an overloaded individual who is a bottleneck merits a judicious and diplomatic approach.

Alleviating bottlenecks in overloaded processes is a study unto itself and largely beyond the scope of this article. Suffice it to say, the subject process should be standardized as much as possible in order to make it stable enough to analyze for improvement. Issues of process capacity and bottleneck relief are informed by the Theory of Constraints (TOC) (Goldratt & Cox, 1994). To apply the TOC, there are the "4 Steps of TOC," which are broadly applicable to any process (Sheinkopf, 1999):

* Identify the constraint.
* Decide how to exploit (i.e., alleviate) the constraint.
* Subordinate and synchronize everything else to the first two decisions.
* Elevate (i.e., improve) the performance of the constraint.

Solutions may result in process changes to eliminate other forms of waste, as well as improvements to increase the effective capacity of the bottleneck in the process.

Liker (2004, p. 29) suggests an eighth source of waste, "Losing time, ideas, skills, improvements and learning opportunities by not engaging or listening to your employees." Brue and Howes (2006, p. 352) echo the idea that *underutilizing people* is a waste, but suggest it is the least obvious source of waste because companies and managers might not be aware of the potential. Perhaps this oversight occurs because of their information overload: either the employees are too overloaded to show their true potential, or the managers are too overloaded to perceive it.

Discussion

Trends E-Magazine, in its October 2009 issue, in its analysis of the trend of information overload, offered four forecasts related to the trend (pp. 33-34):

1. There is a rising wave of backlash against information technology, and reassessing so-called productivity tools.
2. To respond to this backlash, there will be a surge of companies offering solutions. This sort of problem is much more likely to see a successful solution coming from a complete unknown in a small entrepreneurial start-up.
3. Many of these contenders will go by the wayside.
4. The most promising solutions to information overload are likely to be social and behavioral rather than technological.

Etzel and Thomas (1996, p. 15) went so far as to suggest that the individual should use her brain more effectively, i.e., improve her memory, rather than rely so heavily on technology. While a better memory may not be an option for some individuals, the idea that social and behavioral changes offer promising solutions are reinforced by the propositions offered in this article.

Propositions

The scientific management of information overload suggested here is based on three key principles: the need for direct observation, the standardization of tasks, and the elimination of waste. Based on the analysis presented here, the following propositions are offered:

P1: To address the problems of information overload, the individual must first use direct observation to understand the scope of the problem.

P2: Cross-referencing an individual's roles and information actions provides a catalog of information needs, tracked over time.

P3: Applying gap analysis to the catalog of information needs will enable the individual to reduce the overload and improve the quality of information use.

P4: Standardization of information handling is needed to identify sources of waste in information processes.

P5: Reducing waste in information processing will further alleviate information overload.

These propositions have been illustrated with anecdotal evidence and can be further tested for more rigorous application. Specific changes identified in the preceding analysis are summarized in Table 1 and labeled as behavioral (B), social (S), or technological (T) in nature.

Table 1: *Suggestions by Type of Waste*

Type of Waste	*Suggested Change*
Overproduction	Pull needed information instead of receiving pushed communications (B) Use cognitive filters (B) Establish communication policies and value-added culture (S) Apply computer filters to incoming information (T)
Excess inventory and work in process	Break habit of multi-tasking (B) Avoid keeping information "just in case" (B) Schedule uninterrupted time for focused work (B) Conduct regular "decluttering sessions" (B) Limit the number of open projects at one time (S)
Unnecessary transportation	Create a "dump zone" to contain information to be processed (B) Establish an organizational system to process incoming information (B, T) Organize work areas using the 5S technique (B)
Defects and mistakes	Maintain focus resulting from direct observation and gap analysis (B) Establish poka yokes to prevent or detect mistakes (B, T)
Unnecessary processing	Avoid "tool abuse" and match the medium to the message (B) Craft email and voicemail messages to be more informational (B, S, T)
Unnecessary human motions	Employ visual cues for information access (B)
Waiting	Make good use of waiting time (B) Address individuals who represent bottlenecks (S) Alleviate constraints of bottlenecks in processes (S, T)

Conclusion

While the propositions and anecdotes and suggested changes might not be considered rigorous, the logic underlying this analysis is sound. It has been argued that Taylor's thinking was a direct influence on Henry Ford and subsequently on the Toyota Production System and lean production. Core tenets of these management practices can be applied to the information overload of knowledge workers, a key challenge of the current age. The legacy of Frederick W. Taylor thus remains relevant for the 21st century.

References

Ale Sandrini, K. (1992). SURVIVE™ *Information Overload: The 7 Best Ways to Manager Your Workload by Seeing the Big Picture.* Homewood, IL: Business One, Irwin.

Allen, D. (2002). Getting Things Done: The Art of Stress-Free Productivity. NY: Penguin.

Anand, G. & Kodali, R. (2010). Analysis of lean manufacturing frameworks. *Journal of Advanced Manufacturing Systems, 9*(1): 1-30.

Bawden, D. (2001). Information overload. *Library & Information Briefings*, 92.

Brennan, L.L. (2006). Operations management for engineering consulting firms: A case study. *Journal of Management in Engineering, 2*(3): 98-107

Brennan, L.L. & Orwig, R.A. (2000). A tale of two heuristics: Conflicting approached to work allocation. *Engineering Management Journal, 12*(3): 18-25

Broida, R. E-Mail Strategies: Attachments, Subject Lines. *PC World*, September 09, 2009. Accessed online at http://www.cio.com/article/print/501650 on June 7, 2010.

Brue, G. & Howes, R. Six Sigma. New York, NY: McGraw-Hill.

Chase, R.B. & D.M. Stewart. (1994). Make your service fail-safe. *Sloan Management Review, 35*(3): 35-44, (reprint 3533).

Chewning, E.C. Jr. & Harrell, A.M. (1990). The effect of information load on decision makers' cue utilization levels and decision quality in a financial distress decision task. *Accounting, Organizations, and Society, 15*: 527-42.

Crosby, P.B. (1980). *Quality is Free*. New York, NY: Penguin Books.

Crovitzthe, L.G. (2008). Unloading Information Overload. *The Wall Street Journal,* July 7, 2008. Accessed online at http://online.wsj.com on February 8, 2010.

Drucker, P.F. (1968). *The Age of Discontinuity*. HarperCollins Publishers.

Emerson, H.P. & Naehring, D.C.E. (1988). *Origins of Industrial Engineering: The Early Years of a Profession*. Industrial Engineering & Management Press.

Eppler, M.J. & Mengis. (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. *The Information Society, 20:* 325-344.

Etzel, B. & Thomas, P. (1996). *Personal Information Management*. NY: New York University Press.

Feld, W.M. (2001). *Lean Manufacturing Tools, Techniques, and How to Use Them.* Boca Raton, FL: St. Lucie Press.

Gawande, A. (2009). *The Checklist Manifesto: How to Get Things Right.* New York, NY: Metropolitan Books.

Goldratt, E.M. & J. Cox. (1994). *The Goal: A Process of Ongoing Improvement, 3/e.* Great Barrington, MA: North River Press.

Goldsborough, R. (2009). Battling information overload in the information age. *Tech Directions, April 2009, 68*(9): 13.

Hemp, P. (2009). Death by Information Overload. *Harvard Business Review*, September 2009, 83-89. Reprint #R0909J.

Ireland, L.R. (1991). *Quality management for Projects and Programs*. Sylva, PA: Project Management Institute.

Jaques, R. (2005). Corporates look for ways to tame the data monster. *Financial Director*, September 2005: 48.

Henderson, B. & Larco, J. (1999). *Lean Transformation. How to Change Your Business into a Lean Enterprise*. Richmond, VA: The Oaklea Press.

Kanigel, R. (1997). The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency. New York, NY: Penguin Group.

Levinson, M. (2010). E-mail Etiquette: 8 Tips to Avoid Communication Blunders. CIO, May 19, 2010. Accessed online at http://www.cio.com/article/print/594267 on June 7, 2010.

Liker, J.K. (2003). *The Toyota Way: 14 Management Principles from the World's Great Manufacturer*. New York, NY: McGraw-Hill.

Ophir, E., Nass, C. & Wagner, A. (2009). *Proceedings of the National Academy of Sciences of the United States of America* (9/15/2009). 106(37): 15583-15587.

Peek, R. (2010). My not-so-overloaded new year. *Information Today*, January 2010: 15-16.

Peterson, B. (2010). Taking lean beyond the shop floor. *Industry Week*, April 2010, 41-42.

Schick, A.G., Gorden, L.A. & Haka, S. (1990). Information overload: A temporal approach. *Accounting Organizations and Society, 15*: 199-220.

Sheinkopf, L.J. (1999). *Thinking for a Change: Putting the TOC Thinking Processes to Use*. Boca Raton: St. Lucie Press.

Shih, D., Chiang, H. & Lin, C. (2008). Data mining methods in the detection of spam. *Journal of Business and Management, 14*(2): 117-129.

Simpson, C.W. & Prusak, L. (1995). Troubles with information overload--- Moving from quantity to quality in information provision. *International Journal of Information Management, 15*: 413-425.

Sorohan, E.G. (1994). Coping with overload. T*raining & Development, 48*: 13.

Stebbins, S. (2010). The 10 Habits of Highly Organized People. O: The Oprah Magazine, *11*(3): 153.

Taylor, F.W. (1911). *The Principles of Scientific Management*. New York, NY: The Norton Library.

Thompson, H. (2006). Information overload: An overflowing in-box is a sign that you're not processing things into your organizational system efficiently. *Advisor Today,* November 2006, *98*(2).

Trends E-Magazine. (2009). Trend #6: Managing information overload. Accessed online on July 29, 2010 from: http://www.trends-magazine.com/trend.php/Trend/2051/Category/48.

Tushman, M.L. & Nadler, D.A. (1978). Information processing as an integrating concept in organizational design. *Academy of Management Review, 3*: 613-625.

Womack, J.P. & Jones, D.T. (2005). *Lean Solutions: How Companies and Customers Can Create Value and Wealth Together*. NY: Free Press.

Wurman, R.S. (2000). *Information Anxiety 2*. Canada: Que Publishing.

J.B.M.

Invitation To Review Manuscripts

The review process is a critical step in publishing a quality journal. The editors of the Journal of Business and Management invite you to participate in the ongoing activities necessary to make JBM a reputable scholarly outlet. If you would like us to send you manuscripts to review, please complete the form below or email us with the information at jbm@chapman.edu.

Name____

Address ____

____

____

____

Email____

Please list your major areas of interest:

Please indicate how many manuscripts you would be willing to review in an academic year:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Please return the form to:

Amy E. Hurley-Hanson, Ph.D.
Cristina M. Giannantonio, Ph.D.
Editors, Journal of Business and Management
Argyros School of Business and Economics
Chapman University
One University Drive
Orange, CA 92866

FAX (714) 532-6081

Subscription Form

The Journal of Business and Management is published by the Argryros School of Business and Economics, Chapman University. It is sponsored by the Western Decision Sciences Institute.

The annual subscription fee is $50.00 for individuals and $100.00 for institutions. Your check or money order should be made out to CHAPMAN UNIVERSITY/JBM. Please complete your mailing information below.

Name____

Department____

Address Line 1 ______________________________________

Address Line 2 ______________________________________

Address Line 2 ______________________________________

Tel____

Fax ____

Mail this form with your check or money order to:

Journal of Business and Management
Argyros School of Business and Economics
Chapman University
One University Drive
Orange, CA 92866

email: jbm@chapman.edu

ISSN: 1535-668X
Editorial Offices: Journal of Business and Management
Argyros School of Business and Economics
Chapman University
One University Drive
Orange, CA 92866

Fax: (714) 532-6081

E-mail: jbm@chapman.edu

Submission information is available on our website: jbm.chapman.edu

The *Journal of Business and Management* is published by Chapman University's Argyros School of Business and Economics with the sponsorship of the Western Decision Sciences Institute. The primary editorial objective of the *Journal of Business and Management* is to provide a forum for the dissemination of theory and research in all areas of business, management, and organizational decisions which would be of interest to academics and practitioners.

CHAPMAN
UNIVERSITY

The George L. Argyros
School of Business and Economics
One University Drive
Orange, California 92866

VOL. 17, NO. 1, 2011 JOURNAL of BUSINESS and MANAGEMENT CHAPMAN UNIVERSITY