The science behind Taylor's 'principles of scientific management'

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The concept of Taylor's scientific management dominated during the middle of the twentieth century, in spite of early and strong criticism about the dehumanizing effect of its mechanistic approach to work on the workforce. While not wanting to join in the pro- and con-debates, this paper analyses where Taylor's propositions are still valid, albeit updated, by exploring the 'science' and the 'management' of his theory.

Taylor maintained that scientific management is generic and applicable to all levels and to all groups. The challenge was to determine what is meant by a science or sciences of human society; how do the underlying laws, rules and principles of the different sciences apply to different groups of society; and how relevant are Taylor's concepts today, are they still around, where and to what effect?

Results from this evaluation indicate that, as alluded to by Taylor, scientific management is not a single science, but a combination of different natural sciences, including mechanical and life sciences, and therefore subject to different natural laws. It is furthermore not a generic theory, not applicable to all groups, but versions of the mechanistic application are still very much alive and valid in certain identifiable organizational sectors and functions.

A century after the publication of Taylor's theory of scientific management, the challenges, already partially acknowledged by academics and organizations, should be to accept that earlier concepts by theorists like Taylor are still valid today within different types of science, supported by different laws and applicable to different groups, yet interrelated. Accepting the importance of scientific perspective the focus of research can move on from debating the differences, to addressing questions of whether the continued insistence of processual improvements can be sustained and who are the real winners and losers of scientific management.

Keywords: scientific management, mechanical science, life science, production, manufacturing, services

1. Introduction

In 1911 Frederick Winslow Taylor presented a paper to the American Society of Mechanical Engineers (ASME) in which he argued for the general acceptance of his principles of scientific management to improve the productivity of organizations, and subsequently the economic welfare of the nation (*Taylor* 1911). The underlying concepts, benefits and limitations of Taylor's principles have been well researched and documented over the past century, resulting in theoretical schools of thought either accepting and improving on, or rejecting some of the theories of scientific management (*Morgan* 2006, *Shenhav* 1999, *Djelic* 1998, *Kanigel* 1997, *Pruijt* 1997, *Wood* 1993). Instead of siding with one or the other of these movements, the objective of this paper is to explore the principles of scientific management as presented in 1911 in more detail by looking at the circumstances surrounding the theories; the science behind the principles; and the validity of the claims made by Taylor at the time of his propositions and a century later.

The paper is presented in three parts. The first section addresses what is meant by a science or sciences of human society and organizations. It explores some of the various interpretations of the term science and proposes to use a framework suggested by *Radcliffe-Brown* (1957, p. 9.) to be used in the evaluation of Taylor's principles of science.

In the following section Taylor's principles of scientific management are introduced and analyzed separately as the 'mechanisms of management' and 'essence of management'. Taylor used these terms to separate his principles applicable to task improvement as opposed to his principles applicable to the people management within organizations. The principles and their underlying sciences are viewed in 1911 and one century later in order to establish reasons for the introduction, change over time and their validity today.

The final concluding section summarizes the findings and identifies impacts and areas for further research.

2. Defining science

2.1. Radcliffe-Brown's single science for the study of human society

Science is a wide concept that is generally interpreted differently by various audiences. The Oxford definition of science states that it is "the systematic study of the structure and behavior of the physical and natural world through observation and experiment" (*Oxford English Dictionary* 2007, p. 295.). This definition focuses on the ability to substantiate the study findings of the natural and physical world, therefore seemingly excluding philosophy and theory about aspects of the natural world which are, as yet, not observable. It is also interpreted differently within different specialist subject areas such as engineering in which most of the physical world is viewed and studied as an exact science (*Peaucelle* 2000); and economics in which probability and uncertainty are regarded as integral to simulation models (*Wagner-Tsukamoto* 2007).

I would, however, like to revisit a comprehensive definition of science presented by Radcliffe-Brown in his proposal for a single branch of science for the study of human society (*Radcliffe-Brown* 1957). Radcliffe-Brown, an anthropologist, introduced his theses at a University of Chicago conference in 1937. He maintained that this single branch of science should consist of four types of science covering abstract, natural, applied sciences and the arts (*Radcliffe-Brown* 1957, p. 9.).

According to Radcliffe-Brown and widely accepted today (*Radcliffe-Brown* 1957, Plotnitsky in *Gaffney* 2010, p. 298.), abstract sciences are based on logical thinking, either within known natural laws, or by proposing natural laws, concepts and theories in fields where phenomenal observation is either not possible or not yet feasible and include philosophy, theoretical mathematics, theoretical physics and theoretical psychology. Natural science, based on known natural laws, has as its objective the testing of theories and propositions developed by the abstract or theoretical sciences through observation, experimentation, measurement and validation, thereby allowing knowledge to be accepted as epistemologically real. Radcliffe-Brown included sciences such as the exact science of mechanics and chemistry, and the life science of physiology and psychology in this category.

Applied sciences, as implied in the title, build on the knowledge obtained from natural scientific studies to develop solutions to problems or to enhance the development of practical applications, and include engineering and medicine as examples. Arts as the fourth proposed type of science, is concerned with the sensual representation of the knowledge derived from the other fields, thus allowing the knowledge to be spread, understood, and appreciated by a wider audience (*Morgan* 2006, p. 174.).

Radcliffe-Brown accepted that abstract sciences of philosophy and theory, and applied sciences of economics, engineering, law and politics already existed at the time of his theses. He was, however, concerned about the absence of natural sciences about the actual functioning of societies and organizations resulting in 'trial and error' application of theories and beliefs (*Radcliffe-Brown* 1957). Taylor's principles in 1911 can be presented as an

example of abstract propositions which were trialed in some organizations with mixed results, but not yet fully explored and tested through natural scientific means of research.

An analysis of Taylor's principles of scientific management will consider the principles in the light of the prevalent different types of science in which abstract science and applied science are referred to. However the focus is on the natural sciences and their underlying laws of nature and how Taylor's principles of scientific management can be interpreted within these sciences.

2.2. Natural sciences 1911 to 2011

The natural sciences which were dominant at the time of Taylor's propositions were exact science of mechanics and life science (*Silver* 1998, pp. 226–227.; *Radcliffe-Brown* 1957, p. 9.) and these have since been enhanced by the subsequent evolving sciences of uncertainty and chaos during the twentieth century (*Gleick* 1995).

The fundamental assumptions of classical physics and mechanics at the start of twentieth century were predominantly based on the laws of Newton (1642–1727) around a body's position based on its mass, acceleration and force. The universe, for instance, was regarded as a giant machine set in a framework of absolute time and space in which complicated movement could be understood as a simple movement of the machine's inner parts, even if these parts could not be visualized (*Kibble–Berkshire* 2004, pp. 1–15.). The Newtonian laws were based on the concepts of cause and effect, and of determinism. If a body exhibited motion, one could always figure out what was producing the motion, while the concept of determinism stated that a future position of motion could be determined from its current known state by changing the observer's probing and extent of adjustments. It was this belief in the laws of mechanics and the ability to rely on cause and effect to predict the outcome of changes to processes that encouraged Taylor and other classic organizational theorists to propose the transfer of these laws to organizations through the systemization of functions and processes (*Morgan* 2006, pp. 16–17.; *Burrell–Morgan* 1979, p. 128.).

Even during the time of Taylor's theses, physicists and mathematicians moved on from the exact Newtonian laws to include theories of uncertainty, such as the theories of relativity and chaos (*Silver* 1998, *Gleick* 1995). An element of uncertainty and unpredictability was introduced by stating that outcomes cannot always be predicted and that there are systems in which the outcome of a series of events is very sensitive to conditions and for which outcomes are better presented as patterns rather than linear predictions. The theories, based on mathematical models, are generally used in modeling various economic, populations and group trends and behaviors (*Gleick* 1995, pp. 9–32, 57–118). The sciences of uncertainty were still at a philosophical and theoretical stage of development at the time of Taylor's principles of scientific management.

Life science, regarding an organization or society as a living entity, was already promoted by theorists at the time of Taylor's principles of scientific management. Theorists like Spencer, Taylor and Fayol viewed societies and organizations as living bodies focusing on essential functions required for its survival (*Ritzer–Goodman*, 2004a, pp. 106–127.; *Morgan* 2006). However, organizations were viewed with a mechanistic slant in which processes were regarded as important and workers merely as passive and responsive participants (*Burrell–Morgan* 1979, p. 127.). Subsequent organizational theorists in the metaphor of organizations as organisms such as Burns and Stalker, Woodward and Parsons continued to focus on essential management functions to ensure the continued survival of organizations, but this time within its environment as open systems (*Morgan* 2006, pp. 33–70.). However, Radcliffe-Brown and organismic theorists like Maturana and Varela viewed organizations as living entities to be studied by exploring the interrelationships among individuals and functions required for the self-maintenance of the organization (*Burrell–*

Morgan 1979, p. 52.; *Maturana–Varela* 1980, p. 88.; *Silver* 1998, pp. 321–322.; Parsons in *Ritzer–Goodman* 2004a). These structural interrelationships were interpreted as mutual 'contracts' between the individuals and the organizations.

The Hawthorne studies of Mayo during the late 1920s raised awareness for the needs of the individuals in organizations, resulting in psychologists such as Mayo, Maslow, Herzberg and McGregor to focus on their needs and aspirations not only with respect to fairness and equality at work, but to promote job enrichment and the self-realization of the employee (*Morgan* 2006, pp. 35–37.). The introduction of psychology of the individual within organizations developed into another life science to be considered within the single branch of science for human society.

We therefore have different dimensions of sciences and mathematics impacting on Taylor's propositions. In 1911 both the exact science of mechanics and the life science relied on cause and effect and determinism to guide action and predictions. While the science of mechanics is still valid in the physical world, elements of uncertainty based on patterns and interrelationships were added during the twentieth century, especially when the focus moved from the physical inanimate world to include individuals within society and organizations. The life sciences as applied to organizations by theorists during the twentieth century accepted organizations as independent entities, but tended to focus on structure and environment, thereby reducing the original emphasis of functions of the classical management theorists. The role of the individual within organizations gained prominence in theories of agency versus structure (*Morgan* 2006, *Ritzer–Goodman* 2004b).

3. Taylor's principles of scientific management

3.1. Introduction to Taylor's principles

It was within this context of the accepted abstract, natural and applied sciences of mechanics that Taylor presented his principles of scientific management at an engineering conference in 1911.

Forerunners of the concept of a systematic or scientific model of management in Europe can be traced back to its introduction in the army by Frederick the Great of Prussia in the eighteenth century in which he used a modified Roman model to instill discipline and effectiveness in the 'unruly mob' he inherited as an army. This approach was further developed by Adam Smith, a Scottish economist, and promoted in 1776 in his book 'The Wealth of Nations'. The objective was to improve the efficiency of organizations during the Industrial Revolution (*Morgan* 2006, p. 16.) by reducing the discretion of workers, introducing task specialization and standardizing parts and material.

Unlike the European model of classical management theories, the American model for management and productivity grew out of engineering practices in major manufacturing firms during the late nineteenth century (*Shenhav* 1999, *Djelic* 1998). As early as the 1880's members of the American Society of Mechanical Engineers (ASME) started an industry-wide movement to standardize and systemize the technical and operational environment, especially in the manufacturing industry (Shenhav in *Tsoukas–Knudsen* 2003, p. 187.). As an engineer Taylor was part of the movement to introduce systemized and scientific management in companies to increase their production. These concepts were regarded as objective and advantageous not only to the organizations, but throughout the country, as stated by Miller and O'Leary:

> "Systems were perceived as a safeguard for the morality of organizations, of managers and of employees. They bind individuals in mutual relations of responsibility and accountability, depersonalized these relationships, and thus

eliminated favoritism and nepotism. In systems the trajectory of progress can be charted both for individuals and for the organization as a whole, since authority is no longer derived from privileged social positions but is grounded in facts and techniques needed to perform and coordinate interdependent tasks" (*Miller–O'Leary* 1989).

In his presentation on the principles of scientific management at an engineering conference in 1911, Taylor asserted that he offered his theories as a remedy for the loss suffered in the United States as a result of the general inefficiency in the daily life and operations of the population and organizations. Even at this early stage of introducing scientific management, Taylor, however, warned about potential pitfalls in the implementation of the theory in practice, and warned that there is a distinct difference between what he called the 'mechanisms' and 'essence' of management. He acknowledged the difference between his proposed use of science in management techniques to improve processes and the importance of the effect on staff through his essence of management. This aspect of his principles of management focused on the organization as a living entity and the fact that the individuals within this entity may not be as compliant as inanimate physical objects or machines. He therefore asserted that successful implementation of his mechanisms of management can only be successfully achieved through harmony and cooperation.

How successful these principles and the claims actually were will be explored by analyzing his mechanisms and essence of management concepts separately, both at the time of their introduction in 1911, and as surviving today in 2011.

3.2. Taylor's mechanisms of management

Taylor's mechanisms of management concepts were very much based on the improvement of processes to benefit the organization, society and subsequently the individual. In line with the reductionist and determinist view that process improvement can improve the overall position, he proposed "the golden rule of scientific management…: 'Get the situation right, and the appropriate human behavior and organizational performance will follow'" (*Burrell–Morgan* 1979, p.128.).

The mechanisms of management proposed by *Taylor* (1911) specifically addressed the use of systematic scientific techniques to obtain optimum productivity and efficiency, in other words, a focus on the processual improvement of tasks. He proposed that by focusing on task specification through time and motion studies; continuous improvement of techniques such as routing systems; the use of exact measurements and calculations with the aid of slide-rules (today it will be electronic devices); the standardization of tools, material and implements; and by emphasizing maximum in place of restricted output, the production output and financial position of the organization can be improved. Taylor also proposed that it may be beneficial to study the operational methods applied by skillful external individuals or organizations and select the best elements of their methods in order to develop a preferred process for your own application.

Taylor presented evidence of the application and perceived successes of his techniques in different organizational situations and claimed that his principles can be applied to all different groups, such as individual families, farms, religious institutions, charitable organizations, universities, governmental departments, in addition to the large industrial organizations which he referred to in his case studies (*Taylor* 1911).

3.2.1. Mechanisms of management: concerns

Concerns about the validity of the strict application of systemization based on the laws of mechanics in organizations were already identified and recognized by Taylor in his

presentation in 1911. He referred to two main types of concerns, namely concerns about the actual mechanistic and systematic method to identify and improve the processes and concerns affecting the people involved in the changes.

Taylor warned that continued increase in output can lead to reduced performance and reduced quality by stating that "one of the dangers to be guarded against, when the pay of the man or woman is made in any way to depend on the quantity of work done, is that in the effort to increase the quantity the quality is apt to deteriorate" (*Taylor* 1911, p. 32.). He also maintained that the impact of improvements should be considered within a wider context including its impact on customers or society. Taylor realized that the exact laws of mechanics may not always apply when introduced to improve the operations of organizations, or for all groups in society.

On the human element Taylor re-emphasized his distinction between mechanisms and essence of management by stating: "The mechanisms of management must not be mistaken for its essence… Precisely the same mechanism will in one case produce disastrous results and in another the most beneficent… will lead to failure and disaster if accompanied by the wrong spirit in those who are using it" (*Taylor* 1911). Morgan in his Images of Organization summarized the criticisms raised by subsequent organizational theorists on the limitations of the classical, scientific and bureaucratic management theories as: the possibility that it can create organizations that have difficulty to adapt to change; result in the inefficiency of mindless and unquestioning bureaucracy; and have a dehumanizing effect on employees (*Morgan* 2006, p. 28.).

The standardization of tools and, to a certain extent tasks, assisted in the general improvement of operations. However, workers could not be expected to be compliant, predictable and as efficient as machines or robots. The mechanistic laws of cause and effect may be applicable to routine functioning and operating of production line machinery and equipment, or even routine processes where repetition and consistency of output are important. However, unlike Taylor's claim that his principles of the mechanisms of management are universally applicable to all groups, the subsequent development of mathematical sciences of uncertainty and chaos were found to be more acceptable for the analysis of non-routine group behavior or non-routine tasks.

3.2.2. Mechanisms of management: 2011

Taylor's principles of the mechanism of management focused on systematic identification and specialization of tasks; standardization; and the scientific improvement of the processes to benefit production, the organization, the individual and the customer.

The evidence from a scientific point of view is that these principles of cause and effect and determinism based on the exact laws of mechanics are still applicable to certain types of organizations and routine processual tasks and therefore as valid today as in 1911, albeit updated with the latest techniques and technology. Supporters of post-Taylorism and Neo-Fordism accept revisions to the original mechanisms of management and identify techniques such as just-in-time (JIT) production and business process re-engineering (BPR) to achieve objectives of efficiency, short delivery times, quality, diversity, flexibility and increased output (*Peaucelle* 2000, *Wood* 1993) as summarized by Peaucelle:

> "Taylorism is well known, for the organizational techniques that it implements. Post-Taylorism innovates with new ways of working but its initiatives, in many ways, resemble its predecessor. One may argue that these organizational techniques are inconsistent with corporate objectives. Over and above the simple aim of maximising profit, the Taylorian enterprise works to produce more goods at low cost. In the post-Taylorism enterprise, the objective of efficiency is complemented by those of short delivery times, quality, diversity and flexibility.

> In order to attain these new objectives, and still remain coherent with previous ones, enterprises have developed new techniques: just-in-time production, business process re-engineering, call centres, simultaneous engineering, and asynchronous teamwork across networks. According to the hypotheses put forward, post-Taylorism adds new objectives to Taylorism. The strength of today's reorganizations lies in attaining these objectives simultaneously. The consequences for people, however, in terms of their relationships with work, do not necessarily change" (*Peaucelle* 2000, p. 452.).

Similar to Taylor, Peaucelle believes in the validity of exact science of mechanics underlying the application of scientific management in the operations of various organizations. He referred to the wider impact of the introduction of Taylor's mechanisms of management, not only on the profitability of the organizations, but also on the wider customer market through the production of more and therefore cheaper products. However, Peaucelle also warns against the danger of ignoring the impact of these principles on people, in other words, the essence of management.

Various case studies can be identified supporting the implementation and operation of the mechanistic principles underlying Taylor's scientific management, not always successful. *Bayo-Moriones* et al (2008) researched the factors influencing a successful implementation of just-in-time (JIT) systems and found that it can be applied in any production context, although "more concretely, non-metallic mineral products, paper and textile industries present a lower level of adoption of some JIT practices. This is consistent with the reluctance to the introduction of organizational innovation found for these sectors… (*Bayo-Moriones* et al 2008, pp. 1059–1060.). Like Taylor, they found a positive and significant relationship between work organization and the implementation of JIT practices in certain sectors in conjunction with the importance of employee participation and involvement to ensure successful introduction of new methods and techniques in production organizations.

In addition, successful implementation of the principles of systematic and mechanistic management can be found in service organizations such as fast-food outlets or call centers. This model is today referred to as 'McDonaldization' and is accepted as an efficient and standard model followed by some organizations in which a standard level of routine service is important. Tasks are systemized, employees selected and trained for specific tasks and the level of service closely monitored and controlled. Although regarded by some theorists as dehumanizing to the affected employees, the customers and management can rely on consistency in the level and standard of service (*Royle* 2006, pp. 757–779.; *Morgan* 2006).

Taylor (1911) recommended that an organization's processes can be scientifically improved by exploring the methods employed by skillful experts in the process and then by selecting and improving on their best approaches. This method can be detected in current rationalization projects especially to improve customer services. In their research into the development of a 'well-being' model for the Canadian health service, *Chreim* et al (2007) highlighted the importance of external research into similar success models before deciding on a suitable model for the Canadian health service.

The exact science of mechanics which underwrote Taylor's mechanisms of management are therefore mainly found to be effective in manufacturing and production organizations where production line equipment is used, or in certain service industries, where the tasks can be broken down into routine steps that can be rationalized and offered as a standard service to the customer as well as the organization. Innovative organizations, group demonstrations or local communities are modeled mathematically through algorithms based on uncertainty and self-referencing. Tasks are too flexible to mechanize and the underlying rules and patterns proposed in chaos theories are therefore more applicable to the performance of these groups (*Gleick* 1995). Exact science accepted as the dominant scientific basis for prediction and

understanding in 1911 changed to include uncertainty as one of the natural sciences to be accepted in certain circumstances.

3.3. Taylor's essence of management

The second aspect of Taylor's principles of scientific management moves the focus from the task and the ability to determine and forecast outcomes of improvements, to the human element from the perspective of the workers. It has to be acknowledged that the concepts and practices of management and workers were very different in 1911 from the current accepted norms. Many organizations during the latter part of the nineteenth century were family owned. Wealthy owners searched for the best talent within the industry and then allowed workers and supervisors to determine their own methods of executing the tasks required for maximum profitability (*Taylor* 1911, *Ritzer–Goodman* 2004a).

Two elements were identified by Taylor as unacceptable, both from the point of view of employment, but also for the benefit of the organization. His first concern was the trend in industry to search for ideal leaders and managers of the organization, i.e. the 'ready-made competent man' to perform the task, trained by someone else, and at a high price. He regarded this as ineffective and proposed that it be replaced by scientific management in which case the balance between tasks performed by management and workers could be scientifically analyzed and improved. This led to the second concern raised by Taylor in which he said that the general approach to work by the workers were to 'soldier along'. Without even-handed fairness in employment and hands-on control, workers were found to do the minimum work possible and preferred not to increase the work-pace as it would have been to the detriment and injustice of their trade (*Taylor* 1911).

The essence of management as perceived by Taylor focused on recommendations to address both concerns. Tasks should be reorganized and managers should take on their fair share including the tasks of planning, directing, training and control. Workers and managers should be carefully selected to ensure the right potential for the right position and then trained to their full capacity. Workers should be adequately recognized and fairly compensated for the work performed and not paid the minimum wages that the management can get away with. Managers should take time to win over the confidence of the workers for the successful implementation of changes to their work practices.

In this way Taylor proposed that it can lead to increased output for the benefit of the employees and organization, while the lower prices resulting from this increased output can also benefit the consumers, therefore resulting in an overall win-win situation.

3.3.1. Essence of management: concerns

Concerns about Taylor's essence of management and other classical management theories focused on various aspects. The first concern was with respect to fairness to all workers, a concern raised by Taylor himself. Taylor's concern of fairness to workers, although predominantly motivated by productivity and therefore profit, acknowledged the unbalanced status of management domination and pay inequality during the period of the Industrial Revolution.

Criticism identified by *Morgan* (2006, p. 27.) include the dehumanization of workers by stating that workers were reduced to automatons. The major criticism was against the task specialization and the separation of planning and work execution. Workers were employed as cheap labor instead of being thinkers, thus becoming impersonal objects. Even at the time of Taylor's theses he encountered opposition, especially with respect to treating workers as machines, and he was called to give testimony before a congressional inquiry into the impact of scientific management on workers in 1912 (*Linstead* et al 2009, p. 542.). The outcome of

the inquiry was in Taylor's favor, but resistance was still pursued by organizational psychologists like Maslow in their proposed hierarchies of needs for employees instead of passive treatment as compliant machines (*Morgan* 2006, pp. 35–37.).

Building on the individual needs and rights within organizations, concerns were also expressed about Taylor's plea for harmony and cooperation. Theorists like Burns, Whyte and Starkey (*Morgan* 2006, pp. 163–166.) incorporated conflict in the politics of organizations and regarded it as an integral part of managing organizations. This debate, however, raised the question of conflicting interests between individual and organization, in other words whether the science of psychology of the individual should take preference to the science underlying the study of the physiology of the organization as proposed by Radcliffe-Brown and Maturana and Varela. The study of the physiology of organizations focuses on essential functions required for life and the interrelationships of contractual cooperation between worker and organization towards the continued persistency of the organization as an independent entity (*Silver* 1998, *Dean* 2011, *Radcliffe-Brown* 1957, *Maturana–Varela* 1980). It accepts functional specialization and separation in organizations and at the same time regards fairness as an underlying necessity for success. Interrelationships accept conflict and compromise where and when required.

3.3.2. Essence of management: 2011

Taylor initially resisted the involvement of trade unions within organizations but then accepted their roles as part of a collective bargaining process on behalf of the workers thus advancing the subsequent development of the human resources school of thought (*Linstead* et al 2009, p. 542.; *Nelson* 1992, p. 15.; *Hannagan* in *Smith* 2007, p. 263.). The concepts contained in the currently recognized function of human resource management date back to influential theorists and individuals, including Taylor; organizational owners such as Robert Owen in Scotland; the German theorist Hugo Munsterberg; and American theorists such as Chester Barnard and Mary Parker Follett who offered practical solutions to address the concerns about worker conditions, over-specialization of tasks and the impact on the individuals (*Smith* 2007, pp. 41–42.). Contemporary human resource management responsibilities are to focus on the working conditions of staff within the organization and include tasks such as job design; pay scale equality; staff selection; training and development, all of which formed part of Taylor's essence of scientific management. The implementation of a fair set of ethics and deal for employees did not proceed without resistance, and even today requires an external pressure on organizational governance and ethics in some organizations (*Banarjee* 2007). This part of Taylor's principles of management has become embedded as standard practice within organizations.

The general development and acceptance of organizational and industrial psychology to assist individuals within their work environments changed the criticism of the dehumanizing effect of scientific management principles on workers during the past century. Individuals are no longer accepted as passive tools within organizations and the concept of conflict within organizations is accepted as normal instead of being a pathological situation which should be eliminated in favor of the harmony and cooperation promoted by Taylor (*Morgan* 2006, p. 157.).

Taylor proposed a fair separation of functions, especially between management and workers. This separation has been accepted by organismic theorists and the emphasis moved to role rather than individual in organizations (*Morgan* 2006, *Radcliffe-Brown* 1957, *Hannagan* 2005). However Taylor's claims that mechanistic improvement to all functions can lead to organizational improvements cannot be substantiated. The mechanistic approach relies on the tasks to be routine and therefore able to be improved mechanistically. Internal functions were found to be volume driven rather than routine, essential for existence,

supportive of other functions and operating at arms-length from senior management. Cash flow concerns, as an example, can lead to the demise of an organization but not necessarily due to ineffective or inefficient accounting practices.

An example is the research into the collapse of the Icelandic Bank by *Sigurjonsson* (2010, pp. 33–45.) in which he found the main reasons for the collapse to be a lax attitude towards corporate governance and inadequate risk management from within the organization, the government and society, although the actual collapse was due to inadequate liquidity to underwrite reckless loans and investments. Improving the productivity and specialization in the accounts department would not have prevented the collapse since the reasons were multiple, depended on interrelationships among different functions and eventually a lack of cash. Another example is the research into high absence rates in a call center which applied the principles of scientific management, namely: task specialization, separation of planning and execution of tasks, and relentless controls and performance management to ensure high output and quality. *Taylor* et al (2003) found that it is not only the pressure of targets and monitoring that caused the absence rates to be high, but a seemingly unrelated malfunctioning in the air conditioning system. Management improved the air conditioning system and the general workplace environment, and although they did not change the target and monitoring systems, the absence rates dropped. Workplace maintenance as a survival function was important, and had to be subject to regular checking and servicing, but must also be able to adapt to emergency incidences when required.

Taylor (1911) referred to various organizations and operations as evidence of successful implementation of scientific management. These examples included companies manufacturing shoes and machines; the handling of supplies, such as pig iron in steelworks; machine shop processing in the steelwork industry; the quality inspections in the manufacturing of industrial goods, and bricklaying. All of these functions within the organizations were routine functions in the category of operations, and especially the operations within the sectors of production and manufacturing organizations. Many support functions and functions such as the non-routine design of new innovative products cannot be routinized and mechanistically improved.

4. Conclusion

Radcliffe-Brown offered his theses for a single branch of science for the study of human societies and organizations and raised a concern that natural science as the link between abstract theories and the practical implementation of these theories in the applied sciences has not been established at the time of his propositions. The natural sciences based on the exact laws of mechanics; the mathematical laws underlying uncertainty of relativity and chaos; the life science of organizations as living organisms; and the life science of the psychology of the individual provided a framework to evaluate Taylor's principles of scientific management as presented in 1911 and changed during the past century. By analyzing Taylor's theories from a scientific point of view, the following conclusions could be made towards a better understanding of scientific management.

In 1911 Taylor's principles of scientific management were still theories within abstract sciences, trialed as applications within industrial organizations. As a natural science his principles also did not refer to only one type of science, but at least to the exact science of mechanics as well as the life sciences of physiology and psychology underlying organizational functioning.

In 2011 Taylor's mechanisms of management are, however, still valid in organizations and operations involving routine production-line manufacturing or service tasks. Scientific methods to determine the best processes and improve these tasks for success are still pursued within the industry. Taylor's mechanisms of management were, however, not found to be

generic and not applicable to all groups, as supported by the advances made in the physical and mathematical sciences. His mechanisms of management exclude groups such as unstructured or unrelated social groups that are more prone to uncertainty, although operating within determinable patterns supported by chaos theories.

Taylor's essence of management, focusing on fairness; the separation of tasks and a more balanced systemization of organizations, became part of the evolution of organizations in order to adapt to the different structures required after the Industrial Revolution. The different functions and tasks are now accepted as the norm in organizations. Within organizations, Taylor's plea for improved worker conditions in his essence of management became part of the human resource management function and progressed to include fairness, equality and the introduction of ethical governance in organizations. However, harmony and cooperation were found to be not a pre-requisite for organizational success. Conflict and diverse interests have become accepted as healthy within organizations.

What are the benefits of considering the science behind Taylor's principles of scientific management? In addition to be able to explain the changes in the acceptance or rejection of his principles over the past century due to the new developments in the sciences of uncertainty, chaos and life, the knowledge can guide further research in two major areas:

When and where can the principles be applied in organizations and societies? By identifying the natural science underlying the field of study, it can influence the abstract theorizing around this science, as well as the guiding the implementation of the concepts towards the relevant applied sciences.

What is the real impact of the mechanisms of management on society and the wider environment? Taylor's mechanisms of management proposed a continuous improvement in efficiency, productivity and therefore financial growth of organizations, nations and individuals. This resulted in more and sophisticated equipment to replace individuals; political focus on efficiency drives especially to reduce costs; and an ever-increasing need for higher output to boost the growth of the economy.

Research focus could be extended to include questions such as: What happens to the people that are being replaced by the more efficient machines and operations – can they really effectively keep on providing an unlimited growing consumer market if there are fewer jobs – is it really a win-win situation and who are the real losers? Is there a limit to increased efficiency in order to produce savings and improve productivity and profit, or has this become a false economy by just moving the functions being 'cut' for efficiency to other areas in the organization?

Especially in the current world economic situation, it may be prudent to move the focus forward from whether Taylor's principles of management are valid, to what is the real potential and impact of their continued refinements.

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