Human Capital Evaluation: Determining both the cost and value of a firm's human

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Declaration

I, Edgar Anthony Bradley, declare that the PhD thesis entitled "*Human Capital Evaluation:* is entirely my own original work. I am the sole author and all the sources have been acknowledged by way of reference. Furthermore, this thesis has not previously been submitted at North- West University or any other educational institution

…… ……. 20 May 2020……

Signature Date

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Abstract

Many times, the phrase “our people are our most important asset” is used by company CEO’s. Yet personnel are not included on the balance sheet of any company. There are several reasons for this, including the fact that the personnel are not owned by the company. ***This thesis is informed by a literature survey spanning two hundred years, from the early comments of Joseph Whitworth in the Nineteenth Century till the present and by the writer’s 50 years of experience in industry and academia. The author’s CV is included in Appendix 7.***

What this dissertation attempts to do is put people onto the balance sheet, and to do it in two ways: what the company paid for the asset (that is, what the people cost) and secondly what the company got for its money (that is, what is the value of the personnel asset).

The cost of the asset is determined by using Discounted Cash Flow calculations for every current employee, using their current Cost to Company, their years to retirement and the company’s current Cost of Capital. These costs are then aggregated for all personnel to achieve the cost of the asset. Such a calculation fulfils all the necessary accounting conventions. In a field test of the index, taken at a South African water supply company, the value of the Human Resource was calculated at R98 million.

On the value side of the equation, an index has been devised consisting of four factors and four factors only: Experience, Qualifications, Heath and Intelligence. These four factors have been chosen for the following reasons: Their reproducibility, the fact that they are not self-administered and their correlation with job success. The research has not yielded any other factors which meet these criteria.

These four factors have then been combined into an index with a scale notionally from 1 to 9. All factors are given equal weight and adjustments are made to the values so that they all conform to an approximate 9-point scale. The values of the four factors are added together and divided by four, to achieve a composite index.

In the field test of the Index, conducted at the maintenance department of a South African water supply company, the average values of the four factors were found to be: IQ: 93; Experience: 12 years; Qualifications measured by the SAQA system: 6 years; Health: 9 (estimated). The resultant average and adjusted value is 6.9 on a roughly 3 to 9 scale. This value can be used to compare this company with others in the same industry, nationally and internationally. It is also used to define the ratio Index/Cost of Asset, which in the case in question was 6.9/R93million.

Future work should include analyses of other companies, so that a data base can be constructed for various companies in various industries. Further research is necessary to determine if the equal weighting of the four factors is optimal.

It is further acknowledged that although the approach followed in this research will be of benefit in the assessment of human capital, it is not the be all and end all of company management. An excellent Human Resource still needs to be correctly ***managed*** along the lines of the classic scheme of Investigate, Plan, Delegate, Monitor and Adjust as necessary, followed by the establishment of ***motivational incentives*** as per Herzberg. Finally, even with all the above, there is no substitute for ***passion***, as described in one of the appendices. What the present research has done however is to provide a tool for the assessment of the management itself as a Human Resource, what the company paid for it and what it got for its money.

It is also necessary to note here that to fully implement the technique and prove conclusively that it is a valuable contribution to management science, could take years. We do not have the luxury of time, so validation has been done by interaction with experts in the field and by noting the comments from peer reviews in the published article.

Keywords

Human Capital, Human Capital Evaluation, Human Capital Cost and Value, Benchmarking, Business Intelligence and Turnaround, Change Management, Human Capital Development, Accounting for Human Capital

List of Acronyms and Abbreviations

A: Availability

APM: Advanced Progressive Matrices

BCG: Boston Consulting Group

BMI: Body Mass Index

EQ: Emotional (Intelligence) Quotient

FFM: Five Factor Model

FTE: Full Time Equivalent (employee)

g: General Factor (of Intelligence)

GC: Crystallized Intelligence

GDP: Gross Domestic Product

GF: Fluid Intelligence

GMA: General Mental Ability

HBA1c: Haemoglobin A1c test

HCE: Human Capital Evaluation

HIV: Human Immunodeficiency Virus

HRA: Human Resource Accounting

IQ: Intelligence Quotient

IVETA: International Vocational and Training Association

KPMG: The Anglo-Dutch multinational professional accounting firm: Klijnveld, Peat, Marwick, Goerdeler

MBA: Morbidelli Benelli Armi

MBTI: Myers-Briggs Type Indicator

OEE: Overall Equipment Effectiveness

P: Performance

PPE: Property, Plant and Equipment

Q: Quality

ROI: Return on Investment

SAQA: South African Qualifications Authority

SPM: Standard Progressive Matrices

SPMP: Standard Progressive Matrices Plus

T & E: Training and Investment

WAIS – IV: Wechsler Adult Intelligence Scale – 4th Edition

WW2: World War Two

Definitions

Accounting Convention: An accounting convention is a common practice used as a guideline when recording a business transaction. It is used when there is not a definitive guideline in the accounting standards that govern a specific situation. Thus, accounting conventions serve to fill in the gaps not yet addressed by accounting standards

Accounting Standard: Accounting standards relate to all aspects of an entity's finances, including assets, liabilities, revenue, expenses and shareholders' equity. Specific examples of an accounting standard include revenue recognition, asset classification, allowable methods for depreciation, what is considered depreciable, lease classifications and outstanding share measurement.

Benchmarking: Benchmarking is the practice of comparing business processes and performance metrics to industry best practices as well as best practices from other companies. Dimensions typically measured are quality, time and cost. In project management, benchmarking can also support the selection, planning and delivery of projects.

Validation and Verification: In quality management as described in the ISO standard 9000, *validation* can be expressed by the query "Are you building the right thing?" or "Are you performing the correct task?" and *verification* by "Are you building it correctly?" or "Are you performing the task correctly?" "Building the right thing" refers back to the user's needs, while "building it correctly" checks that the specifications are correctly implemented by the system.

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Chapter 1: Introduction

The most valuable of all capital is that invested in human beings"
Alfred Marshall, *Principles of Economics, 1920*

1.1 Chapter 1 Overview

CEOs of companies have for years stated that their employees are their most important asset, but their accountants have generally not been able to quantify this human capital on the balance sheet.

In an attempt to rectify the above problem, the author of this work has adopted the simplest possible approach – hence his invoking of Ockham's Razor, an ancient research paradigm.

Also stated in this introduction is a justification for this work being performed in the Department of Mechanical Engineering, as many engineers have been contributors to management science in the past. Two examples of such engineers are given.

This chapter also covers the Problem Statement, the Importance of the Study, the Aims and Objectives of the Study and the Expected Outcomes and Deliverables.

What must also be stated is that, although this thesis is an attempt at a numerate answer to a long-standing problem, there are important points which cannot be reduced to figures. The most important of these is Passion for the job, also described as Determination or even as "Grit".

Apart from all the above, *Management* is also important in two respects:

- Provision of the entire infrastructure required by the persons in the organisation
- Providing Leadership in terms of providing an example for people to follow and to provide the essential motivational atmosphere in which passion may develop

The Research Methodology employed is simply that of a Literature Survey, informed by the author's 50 years of experience in industry and academia.

The validity of the approach is informed to a large extent by the seminal work of Schmidt and Hunter (1998) as regards the measures which are important in staff selection, what the company gets for its money from the staff, such as IQ. On the other side of the equation, what the company investment is in the staff, a measure which could be part of a balance sheet, is informed by the well-established technique of discounted cash flow, as described originally in the book Capital Budgeting (Dean 1951)

1.2 Ockham's Razor

William of Ockham (1285 – 1347) was an English cleric and philosopher who enunciated the *Principle of Parsimony*, also known as *Ockham's Razor.* It is here rephrased in modern language by philosopher Bertrand Russell (1918): *When considering hypotheses, no more things should be presumed to exist than are absolutely necessary.* The writer has attempted in this thesis to apply this rule, or some extension of it. In other words, his treatment of the subject of Human Capital is the simplest necessary and, he believes, valid in its findings. More factors could have been included, but they would have violated the basic rule of non-subjectivity which he determined in advance to apply. In other words, he has not included any factors which are self-assessed by a person, such as personality tests, even though many would think that such personality assessments are integral to any Human Capital Evaluation.

1.3 Justification for this study

It may be questioned why the present study is being presented in the School of Mechanical Engineering, seeing as it is more about management than engineering. The writer wishes to say that many engineers have been interested in management science and several have contributed to the advance thereof. To name but three examples, J Edwards Deming was an engineer first, before becoming a statistician and management consultant. Rensis Likert another management consultant, studied civil engineering before transferring to other disciplines. The founder of the Boston Consulting Group, now known for consulting in business policy and marketing, Bruce Henderson, was a mechanical engineer to begin with. So, the present writer, although not claiming any equality with the above geniuses, does claim that he operates in their tradition and by their example.

1.4 Accounting Background

"The purpose of accounting is to accumulate and report on financial information about the performance, financial position, and cash flows of a business. This information is then used to reach decisions about how to manage the business, or invest in it, or lend money to it." (<https://www.accountingtools.com> 2019)

The Accounting Tools website goes on to say: "Once this financial information has been stored in the accounting records, it is usually compiled into financial statements, which include the following documents:

- Income statement

- Balance sheet
- Statement of cash flows
- Statement of retained earnings
- Disclosures that accompany the financial statements"

With regards to the Balance Sheet, the website Lexico Oxford states that a Balance Sheet is: "A statement of the assets, liabilities, and capital of a business or other organization at a particular point in time, detailing the balance of income and expenditure over the preceding period." (<https://www.lexico.com/en/definition/balance_sheet>)

1.5 Problem Statement

Many times, in the "disclosures that accompany the financial statements" above, the phrase ***"our people are our most important asset"*** is used by company CEO's. For example, this was a quote from Anne M. Mulcahy, the former chairperson and CEO of Xerox. She was the keynote speaker at LifeCare Inc.'s Life Management 2003 Conference when this quote was made as part of her speech:

"Employees are a company's greatest asset - they're your competitive advantage. You want to attract and retain the best, provide them with encouragement, stimulus, and make them feel that they are an integral part of the company's mission."

Yet personnel are not included on the balance sheet of any company!

There are several reasons for this, including the fact that the personnel are not owned by the company. Even more emphatically it has been cited that particularly in the United States, there is an aversion to the accounting of persons as an asset, because this implies ownership and ownership implies slavery, still deeply imbedded in the American consciousness.

1.6 Importance of the Study

In most cases it is true that people are the most important asset of a business. This was perhaps not so important when a company consisted of well-established technology that did not change much over a long period of time. In the twenty-first century, technological changes are more rapid and occur with increasing frequency. This requires a nimbler, better-educated workforce that is able to adapt to sudden technological and cultural changes. Hence having hard measures to determine and describe the firm's human capital has become more important.

1.7 Aims and Objectives

The Aims and Objectives of the study are as follows:

- To determine what work has been done in the field of human capital evaluation
- To develop the field further
- Specifically, to investigate and then develop methods to determine the value of human capital

1.8 Specific Expected Outcomes and Deliverables

- To determine the two sides of the human capital equation: What a company has paid for its human capital and what it got for the money, in other words, both the cost and the value of the investment. Or to put it economic terms, to develop a method to calculate the supply side and demand side values of the human capital in a company.
- To compare the value of the human capital with the traditional accounting value of hardware capital and how this might vary depending on the technology involved. Some industries such as steel, chemicals and electricity generation have very high hardware capital numbers. Others, such as IT firms have lower values.
- From the point above one might try to develop figures comparing the top performing companies in certain industries with their human capital resource. For example, what is a good ratio of human to hardware capital for a power utility, or a steel mill or for an oil refinery?

1.9 Research Methodology

The research methodology has been simply a literature survey, informed by the writer's 50 years of experience in industry and academia. This experience has enabled the writer to sort out the relevant from the irrelevant information available.

1.10 Validation and Verification

In quality management as described in the ISO standard 9000, *validation* can be expressed by the query "Are you building the right thing?" or "Are you performing the correct task?" and *verification* by "Are you building it correctly?" or "Are you performing the task correctly?" "Building the right thing" refers back to the user's needs, while "building it correctly" checks that the specifications are correctly implemented by the system. In colloquial language, do the right things and do them right. It is possible to perform a task perfectly that should not have been done in the first place (Validation incorrect, verification correct). On the other hand, it is possible to institute a correct task, but not perform it properly (Validation correct, verification incorrect).

In the present study the claim is made that both validation and verification have been performed correctly, as described below.

1.11 Validation

As previously mentioned, industry emphasises the fact that the human resource of any enterprise is its most important asset. So, there is clearly an unfilled need here, the user being company management. Secondly, the literature research has indicated that no valid methodology exists for the valuation of human capital. These two facts provide the validation for the development of a method to determine the value of human capital.

1.12 Verification

The method developed to assess human capital has been verified by application in a South African company.

1.13 Value to Industry and Contributions to the Body of Knowledge

The value to industry will be a heightened awareness of the firm's human capital, and how it interacts with the technology.

The following research has shown that there are four non-negotiable characteristics of human capital: Intelligence, Qualifications, Experience and Health. Furthermore, that the middle two are dependent on the other two – Qualifications and Experience are not of much value if there is not fundamental intelligence to enable them. And Qualifications and Experience, as well as Intelligence, cannot add much human capital value in an unhealthy work force.

Having said this, if must also be emphasised that:

- Good management is necessary to both supply the necessary infrastructure and then to motivate any human resource.
- Some essential characteristics of the human capital are essentially unmeasurable. The most important of these is ***Passion,*** also termed *Determination* or *Grit* (Duckworth 2016) by some authors. This characteristic is qualitative rather than quantitative and must be noted and supported by management. Duckworth explains that it includes Courage, Conscientiousness, Endurance, Optimism and Excellence.
- Finally, it must be admitted that even the most intelligent of persons sometimes do very stupid things, for reasons that are perhaps not fully understood. Hence the need once again for ***management*** of the human resource, to ensure checks and balances as in any human system.

  1.14 Chapter 1: Summary This chapter has set the background for the two sides of the Human Capital scenario: what the organisation paid for it and what it got for its money.

Chapter 2: Literature Review

2.1 Chapter 2: Overview

The Literature Survey demonstrates that importance of human capital has long been understood – at least back to the time of the engineer Joseph Whitworth in the Industrial Revolution in England in the 1800's.

What the survey also demonstrates, however, is that little work has been done over all this time to quantify the value and cost of a firm's human capital.

2.2 Whitworth

In the plethora of literature on the subject of human capital evaluation, there is much of value and some material that is less so. One has to search with discrimination. One very early authority that is worth quoting is given here, which indicates that the necessity for education and intelligence in the workforce has been known, literally, over 160 years. Joseph Whitworth, one of the greatest engineers during Britain's Industrial Revolution, in lamenting on his country's manufacturing prowess being overtaken by the USA, remarked on the superiority of the so-called American Manufacturing System as follows: "The laboring classes are comparatively few in number, but this is counterbalanced by, and indeed, may be one of the causes of the eagerness by which they call in the use of machinery in almost every department of industry. Wherever it can be applied as a substitute for manual labor, it is universally and willingly resorted to. It is this condition of the labor market, and this eager resort to machinery wherever it can be applied, to which, under the guidance of ***superior education and intelligence***, the remarkable prosperity of the United States is due." (Whitworth 1854). Notice that his view was not that machinery could substitute for or replace education and intelligence, but that both were even more necessary than before.

Whitworth's views and those of **Alfred Marshall**, (Marshall 1920) as quoted in the preamble to this thesis, indicate that there has long been an awareness of human capital and its importance for company and even national endeavours.

2.3 Becker

Gary S Becker, in Human Capital Revisited, (Becker 1994) and earlier studies, emphasised the value of education and training as the most important components of human capital formation.

2.4 Deming

J Edwards Deming was an American statistician sent to Japan after WW2 to assist in the rebuilding of Japanese industry. He is held in high regard in Japan as one of the fathers of the Japanese Quality Revolution. In fact, his proposals were eagerly taken up in Japan but not initially in the USA. He is well known for his 14 Points of Management, (Deming 1982), which emphasized leadership by the management, although he does not clearly define what leadership is. It is apparent in his writings however that leadership implies motivation in the way Herzberg defined it. (See below) The writer would describe himself as both an Herzbergian and a Demingite, as he subscribes to both these authors' views.

2.5 Fitz-enz

One of the better sources is the book published by Jac Fitz-enz in 2000, entitled The ROI of Human Capital – Measuring the Economic Value of Employee Performance. The book introduces its author as follows: "Jac Fitz-enz, PhD, is the acknowledged father of human capital benchmarking and performance assessment. He began his breakthrough research in the 1970s."

Dr Fitz-enz covers the history of human capital accounting as follows (p114): "In 1965, Roger Hermanson proposed a method of determining the value of a human being to an organisation. This, along with work at the Institute for Social Research at the University of Michigan, became the foundation for what was then called human resources accounting (HRA). The first attempt by a public company to publish pro forma financial statements that included human assets was the R G Barry Corporation, a small manufacturing company in Columbus, Ohio."

As an engineer, the writer is intrigued to notice that this was an engineering (manufacturing) initiative. In fact, engineers have contributed significantly to areas of accounting and management science, as discussed elsewhere in this treatise.

To return to Fitz-enz: "As more people became involved, articles appeared in various personnel and accounting journals. However, it gradually became apparent that this was a very complex problem requiring expensive long-term research, without any assurance that the problem could be solved. Over the next decade, interest waned and waxed until the topic finally withdrew in favour of more pressing business issues. The principal failure was an inability to agree on how to put a monetary value on people." The writer must beg to differ with the experts here. The method that he proposes "to put a monetary value on people" is, he believes, relevant, correct, precise and simple. This is discussed in later chapters.

Fitz-enz goes on to describe how to put a value on a person: “One has to be able to calculate the variability of a person from four perspectives:

1. Productivity
2. Promotability
3. Transferability
4. Retainability

“The human resources value depends on the value of each of the four factors during the fiscal year. The likelihood of an individual being in any one of those positions – or service states, as they are called – is subject to the law of probability. Flamholtz argued that by using a *stochastic rewards valuation* model, on could determine the following:

1. The mutually exclusive states a person might occupy
2. The value of each state to the organisation
3. A person’s tenure in the organisation
4. The probability that a person will occupy each state at specific future times
5. The expected discounted cash flows that represent their present value

“As intriguing as this problem is, so far, there has been no support from business or professional groups to take it on.”

This writer thinks this is no wonder. Business is basically a simple profession and accounting is, however necessary, a simple matter. No organisation will buy into such a complex scheme. Of the five points mentioned above, only no. 5 is used by the writer in his model.

Fitz-enz goes on to state that at the time of publication of his book in 2000: “the accounting establishment has not yet accepted human capital accounting.” This is not surprising, since dramatic changes and new methods seldom come from within the establishment.

2.6 Flamholtz

To return to Fitz-enz: “Interest (in human resource accounting) grew slowly through the early 1970’s and in 1975, **Flamholtz** (Flamholtz 1996) published the seminal text on the topic.” While studying for his PhD at the University of Michigan, Eric Flamholtz worked as a researcher for the Rensis Likert at the Institute for Social Research. Flamholtz’s doctoral dissertation, which helped pioneer the area of "Human Resource Accounting," was co-winner of the McKinsey Foundation Doctoral Dissertation Award.

2.7 Herzberg

Frederick Herzberg published his milestone paper, “One More Time: How Do You Motivate Employees” in the Harvard Business Review in 1987. In this he posited that employee satisfaction and motivation can be represented on two scales; the so-called hygiene scale and the motivation scale. The hygiene scale includes things like company policy, supervision style, work conditions and significantly, salary. This scale must be filled to a satisfactory level (it can never be completely filled) before any motivation can take place.

On the motivation scale are items such as achievement, recognition, the work itself, responsibility, growth and the possibility of advancement. Only these factors can motivate.

The writer’s experience is that Herzberg’s assertions are true. Even a highly gifted workforce, with a high human capital score, needs to be motivated.

Although Herzberg and Deming did not propose much in the field of Human Capital measurement, they are included as significant in the present study to emphasise that even when a company has a valuable human resource, that resource has still to be properly managed and motivated.

2.8 Marshall

Alfred Marshall (26 July 1842 – 13 July 1924) was one of the most influential economists of his time. His book, Principles of Economics (Marshall 1890), was the dominant economic textbook in England for many years. It brings the ideas of supply and demand, marginal utility, and costs of production into a coherent whole. For our purposes he is famous for the quotation “The most valuable of all capital is that invested in human beings.”

2.9 Schmidt and Hunter

From the point of view of what is required in human capital, the seminal work by Schmidt and Hunter (1998) is still much referenced and has not been improved upon. It is discussed in more detail in the rest of this report. Suffice it to say at this stage that it summarizes the practical and theoretical implications of 85 years of research in personnel selection. On the basis of meta-analytic findings, this article presents the validity of 19 selection procedures for predicting job performance and training performance and the validity of paired combinations of general mental ability (GMA) and the 18 other selection procedures.

Overall, the three combinations with the highest multivariate validity and utility for job performance were:

- GMA plus a work sample test (mean validity of .63)
- GMA plus an integrity test (mean validity of .65)
- GMA plus a structured interview (mean validity of .63)

A further advantage of the latter two combinations is that they can be used for both entry level selection and selection of experienced employees. The practical utility implications of these summary findings are substantial. The implications of these research findings for the development of theories of job performance are discussed.

A note of caution should be sounded about GMA tests. An internet industry has grown up around the concept of GMA. Some of the tests presented are biased in that they are not really intelligence tests, being self-scored and sometimes biased to be politically correct. For the purpose of this thesis only classic IQ tests will be accepted as GMA, as they are reproducible, unbiased and cannot be manipulated by the candidate.

2.10 Schultz

The term "*human capital"* originated with **Theodore Schultz**, (Schultz 1971) an economist interested in the plight of the world's underdeveloped countries. Schultz was such a respected economist that he won the Nobel Prize in 1979. The main thrust of his work was that in the agricultural sector economists were over-emphasising the value of land and under-emphasising the value of the human capital farming the land. He did not, however, propose any method for evaluating the human capital.

2.11 Pfau

Probably the most up-to-date authority on human capital is Bruce Pfau, (Pfau 2001) formerly head of human resources at KPMG and currently a director of the Information Services Group (ISG). He is famous for his emphasis on ***the nurturing and retention of talent as the number one strategic advantage for most companies.***

2.12 Chapter 2: Summary

The conclusion from the literature survey is that a considerable amount of literature has arisen over the past two centuries on the subject of Human Capital, but little has been done to formalise it in accounting principles, for legal and other reasons. This writer thinks the time has come to now formalise it.

Chapter 3: Accounting

3.1 Chapter 3: Overview

This chapter presents a brief history of the accounting profession, accounting proposals for human capital to date and the advantages and disadvantages of human capital evaluation. The writer's proposal for how to perform human capital evaluation is then briefly described, with the advantages thereof.

3.2 The Accounting Viewpoint

"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of *Science*, whatever the matter may be." (Kelvin 1883).

Although the above words are those of a scientist, rather than an accountant, they are applicable to accountancy as well, it being also a science of measurement.

The human always attempts to quantify, to annotate and to collect similar things into a common place. This is the essence of accounting. To know what you have, what its value is and what you paid for it. It is as precise as it can be in the areas it covers. Unfortunately, it leaves one important area vacant – that of human resource accounting.

3.3 The History of Accounting

Alexander (2002) writes that there are seven fundamental aspects with which accounting concerns itself and which are necessary for accounting to function:

- Private property
- Capital aka wealth
- Commerce
- Credit
- Writing
- Money as a medium of exchange and as a quantifier of Capital
- Arithmetic

Although some primitive forms of accounting had been around since 3500 BC in Mesopotamia, before the Middle Ages these seven factors did not exist together, anywhere. In Europe in they came together and led to the most important innovation in accounting practice – the double entry bookkeeping system.

Double entry bookkeeping was described in 1494 by Luca Pacioli in his book *Everything about Arithmetic, Geometry and Proportion* which was a treatise on various mathematical topics, including accounting. Pacioli did not invent the technique but was the first to describe it in a book.

The scene then shifts to Scotland, as the profession of accounting in Italy diminished in the nineteenth century. It is in Scotland that the profession of Chartered Accountant originated. In Edinburgh the profession was long associated with the legal fraternity, whereas in Glasgow accountants were associated with merchants.

In 1880 the Institute of Chartered Accountants of England and Wales was formed. The term CA is now used for the profession in most of the English-speaking world. In the United States the equivalent term is CPA or Certified Public Accountant.

The financial instruments of the Profit and Loss Account and the Balance Sheet are now standardized across the world, the former being exactly what it says, stating the profit (or loss) made by the company over a twelve-month period. The latter is a statement of what the company owns and what its responsibilities to its creditors are, in other words, its Assets and Liabilities.

What is significant from our point of view is that after hundreds of years of use, these accounting instruments still make no attempt to quantify the company's Human Capital, even though company CEOs often refer to the employees as the company's most important asset. What follows is a description of attempts made to date to bring a company's human capital onto its balance sheet.

3.4 Human Capital – Accounting Proposals to Date

Looking at Human Capital from an accounting point of view, the following article by **Smriti Chand** summarises the position:

“Human resource accounting (HRA) is similar in principle to the financial accounting. That is, just as financial accounting reflects the costs of assets such as building and machinery, human resource accounting shows human resources as capital not as expenses. Thus, HRA shows the investment the organisation makes in its people and how their values change over a period of time. In simple words, HRA is a sophisticated way to measure the effectiveness of personnel management activities and the Human Resource Management use of people in an organisation. Let us consider some important definitions of HRA:

“According to the American Association of Accountants (AAA)’, “HRA is a process of identifying and measuring data about human resources and communicating this information to interested parties”. **Flamholtz** has defined HRA as “accounting for people as an organisational resource. It involves measuring the costs incurred by organisations to recruit, select, hire, train and develop human assets. It also involves measuring the economic value of people to the organisation”.

“Now, HRA can be defined as the measurement and reporting of the cost on human resources and their present values to the organisation. The main purpose of HRA is to facilitate the effective and efficient management of human resources of an organisation by making the information available on their acquisition, development, retention, evaluation, etc.” (Chand 2019)

3.5 Objectives of Human Capital Accounting

According to **Rensis Likert,** (1987) the objectives of HRA are to:

1. Provide cost value information about acquisition, development, allocation and maintenance of human resources so as to achieve organisational goals in an effective manner.
2. Enable management of the organisation to effectively monitor the use of human resources.
3. Ascertain whether human assets are conserved, appreciated or depreciated during a given period of time.
4. Assist in the development of effective management practices by classifying the financial consequences of various practices followed by the organisation.

3.6 Advantages of Human Capital Accounting also known as Human Resource Accounting

(Sections 3.6 and 3.7 are extracted from an article by Chand, S, 'HRA: Human Resource Accounting: Meaning, Objectives, Advantages and Limitations, https://www.yourarticlelibrary.com/human-resources)

HRA is useful to organisations in more than one respect. This is clear from the following advantages that it offers to organisations:

1. HRA provides useful information about the human capital in the organisation. Such information enables the manager to take the right decision, e.g., choice between new recruitment and promotions, transfer and retention, and retrenchment and retention.

2. It throws light on the strengths and weaknesses of the employees working in the organisation. It facilitates management in recruitment planning, i.e., whether to hire/recruit people or not

3. HRA also facilitates management to evaluate the effectiveness of HR policies and practices. For example, high costs in training may warrant to look at the returns over a period of time, expenses incurred in the additional recruitment in respect of a particular category of employees may indicate the need for a better compensation plan for them. Besides, HRA also provides feedback to a manager even on his/her own performance.

4. It also provides valuable information for present as well as potential investors to judge a company better on the value/strengths of the human resources/assets utilized therein. If two companies are offering the same rate of return on capital employed, for example, HRA by providing information on their human resources can help the potential investors decide which one company be picked up to make investment. This is because HRA is considered as more accurate accounting method of ascertaining true and fair return on the total resources employed in a firm.

5. Finally, the information provided by HRA enables management to control various types of human resource costs and, in turn, help improve profitability of the organisation.

3.7 Limitations of Human Capital Accounting

However, HRA is not an unmixed blessing. It also suffers from certain limitations as listed below:

1. So far, there are no clear-cut guidelines how to differentiate the 'cost' and 'value' of human resources. Added to it is the uncertainty about human life itself. Unlike physical assets, human assets cannot be owned, retained and utilized at the sweet will and pleasure of an organisation. Not only that, the so-called 'asset' after getting enriched within an organisation may simply disappear attracted by green pastures and, thus, causing loss and inconvenience to the organisation almost suddenly. Given such conditions, it is not easy to value human assets in an organisation.

2. HRA also suffers from measurement problems. There is no consensus as yet among the accountants and finance professionals regarding in what form and manner the human assets are to be valued and then shown in Balance Sheet. This problem gets compounded by the question of recovery /amortising rate. Should the HR costs be amortised at decreasing, constant or increasing rate? Whether the amortisation rate should remain the same or different for different categories of human capital, i.e., employees.

3. There is also a fear that the employees and trade unions may not accept the idea. The reasons are not difficult to seek. Valuing employees at different levels may lead to division among them, on the one hand, and may discourage those valued at lower levels, on the other. Trade unions may dislike the idea mainly because they will have to seek rewards/compensation for employees as per their levels of valuation in the organisation.

4. However, there is not sufficient empirical evidence available so far to support the contention that HRA as a managerial tool facilitates managers in better and effective management of human resources in an organisation."

3.8 Advantages of the Proposed Method of Human Capital Evaluation

The technique developed by the writer covers many of the points in the article above and, more importantly, has answers for the problems as well. In particular, the concerns quoted below are catered for:

- *"There are no clear-cut guidelines how to differentiate the 'cost' and 'value' of human resources."* – The writer's method does solve this problem.
- *'There is no consensus as yet among the accountants and finance professionals regarding in what form and manner the human assets are to be valued and then shown in the Balance Sheet"* – The writer's method presents a valid, accounting-based method of valuation.

3.9 Chapter 3: Conclusion

Having now described the claimed pros and cons of human capital evaluation from an accounting point of view, and how the proposed method solves these problems, the next chapters will describe the process in more detail.

Chapter 4: Human Capital Evaluation (HCE)

4.1 Chapter 4: Overview

This chapter covers some of the work done on the quantification of human capital by persons such as Flamholtz, Fitz-Enz and others. The conclusion is that there is really not much of a body of knowledge to draw on. What is significant however is the work of Schmidt and Hunter, which despite being pre-twenty-first-century, is still referenced often by human resource professionals. The importance of their work is that it demonstrates conclusively the overriding importance of intelligence in work performance and the positive correlations between intelligence and responsibility, consciousness and other desirable attributes.

4.2 Authorities on Human Capital Evaluation

Flamholz and Likert have already been mentioned above. Further information on these authorities and on others, is given below.

4.3 Eric Flamholtz

Flamholtz is currently the Professor Emeritus, Management and Organisations at the Anderson School of Management at UCLA. He began his academic career as one of the founders of the field of human resource accounting, and his book on this subject (Kluwer Academic Press, 1998) is generally recognized as the landmark work in this area.

However, since 1976, Flamholtz' interests have focused rather on organizational growth and development, especially in entrepreneurial firms. His research has led to several frameworks that analyze the key building blocks of organizational success and the transitions required from one stage of development to the next. He has also developed validated methodologies for organizational assessment, strategic planning, performance management and culture management that have been applied by organizations globally.

4.4 Rensis Likert

Likert was an American social psychologist who is primarily known for developing the 5-point Likert scale, a psychometric scale that allows people to respond to questions of interest, in order to measure people's attitudes (such as personality and attitude tests). He also proposed four different management styles, as shown below:

1. Exploitative-authoritative: The first system of Rensis Likert theory is characterized by decision-making in the upper echelons of the organization, with no teamwork and little communication other than threats.

2. Benevolent-authoritative: This Likert system is based on a master-servant relationship between management and employees, where rewards are the sole motivators and both teamwork and communication are minimal.

3. Consultative: In this style, managers partly trust subordinates, use both rewards and involvement to inspire motivation, foster a higher level of responsibility for meeting goals, and inspire a moderate amount of teamwork and some communication.

4. Participative-group: This system is based on managerial trust and confidence in employees; collectively determined, goal-based rewards; a collective sense of responsibility for meeting company objectives; collaborative teamwork and open communication.

Rensis Likert is better known for the above work rather than for his contribution to Human Capital Theory.

4.5 Jac Fitz-enz

In the preface to his book, The ROI of Human Capital, **Jac Fitz-enz** says: “The classic books on management have ignored, avoided, or thrown platitudes at the question of human value in the business environment. When and if the authors did give passing attention to valuing the human contribution, their comments were either gratuitous or simplistic. Nineteenth-century capital theory claimed that wealth was leveraged from investment in tangible assets such as plant and equipment…...no one has successfully taken on the challenge of detailing how to demonstrate the relative value of the human element in the profit equation. Invariably, writers attempting to do so have opted out at the last minute with weak-kneed excuses for not closing the loop with specific examples. The only exception has been some of the human resources accounting work, and that has not been accepted as a practical management tool.”

According to Fitz-enz: “In business terms we might describe human capital as a combination of factors such as the following:

- The traits one brings to the job: intelligence, energy, a generally positive attitude, reliability, commitment

- One's ability to learn: aptitude, imagination, creativity and what is often called 'street smarts,' savvy or 'how to get things done'
- One's motivation to share information and knowledge: team spirit and goal orientation"

"The great irony is that the only economic component that can add value in and by itself is the one that is the most difficult to evaluate. This is the human component – clearly the most vexatious of assets to manage. The almost infinite variability and unpredictability of human beings make them enormously more complex to evaluate than one of the electromechanical components that comes with predetermined specifications. Nevertheless, people are the only element with the inherent power to generate value."

4.6 Theodore Schultz

"The term "*human capital"* originated with **Theodore Schultz**; an economist interested in the plight of the world's underdeveloped countries. Schultz was such a respected economist that he won the Nobel Prize in 1979. The main thrust of his work was that in the agricultural sector economists were over-emphasising the value of land and under-emphasising the value of the human capital farming the land. He did not, however, propose any method for evaluating the human capital."

4.7 The Seminal Work of Schmidt and Hunter

Schmidt and Hunter's studies, although performed in the 90's of the last century, are still referenced by present day Human Relations specialists. The studies were exhaustive and proved that the prime determinant of job performance and therefore of employee value, is intelligence. For example, Bullock (2011) states that:

"In a practical sense, the most valuable attribute of a selection procedure (ie, a personnel assessment method) is the degree to which it successfully predicts future job performance, job-related learning, and other criteria. The term that describes the ability of an assessment tool to predict future performance is called *predictive validity*. The greater the predictive validity of a selection procedure (or some combination of assessment procedures), the better it is at predicting the outcomes described above.

"Selection procedures with high predictive validities also have more value for organizations; via increased productivity, output, and learning ability of their workforce. In a seminal article, Schmidt and Hunter (1998) conducted a meta-analysis on thousands of studies over 85 years

to determine the predictive validity of 19 different selection procedures, both individually and in combination with general mental ability (GMA**)**."

General mental ability (GMA) is a term used to describe the level at which an individual learns, understands instructions, and solves problems. Tests of general mental ability include scales that measure specific constructs such as verbal, mechanical, numerical, social, and spatial ability.

Schmidt and Hunter found GMA (also known as *g*, general intelligence, or general cognitive ability) to ***be the single best tool for selection***. GMA measures have numerous benefits. They are:

- low-cost
- highly predictive of job *and* training performance
- supported by almost a century of research
- predict performance for all types of jobs and at all job levels
- not reliant on applicants having previous experience (as is the case with work sample and job knowledge tests)

"Schmidt and Hunter even noted that GMA can be 'considered the primary personnel measure for hiring decisions, and one can consider the remaining 18 personnel measures as supplements to GMA.' Therefore, according to their findings, the important question in selection is not what *single* procedure should we use? but rather what procedure should be *combined* with a GMA assessment?

"Their meta-analysis found that the three combinations with the highest predictive validity (in decreasing order) were: GMA plus an integrity test, GMA plus a structured interview, and GMA plus a work sample test. The first two can be used with entry-level applicants and experienced employees while the latter can only be used with employees that have previous job knowledge or experience. An integrity test measures conscientiousness as well as aspects of agreeableness and emotional stability. A structured interview has carefully prepared, precisely scored questions based on an analysis of the open position. Finally, work sample tests are composed of real-life simulations of the work to be performed by applicants."

For our purposes, the subsidiary techniques given above viz work sample tests, structured interviews and integrity tests can be discounted as not fitting our criteria being either self-administered or not applicable as balance sheet items. For example, how would one quantify structured interviews in accounting terms? The main finding of the research stands however,

the Intelligence is the number one criterion of workplace performance, a factor which the writer has noticed empirically over his career in several organisations and several technologies.

A table of the actual findings of the Schmidt and Hunter studies is given below. Because of the importance of their research for our purposes, one of their papers is included in full in Appendix 1.

To quote from Schmidt and Hunter themselves:

“This article summarizes the practical and theoretical implications of 85 years of research in personnel selection. On the basis of meta-analytic findings, this article presents the validity of 19 selection procedures for predicting job performance and training performance and the validity of paired combinations of general mental ability (GMA) and the 18 other selection procedures.

Overall, the three combinations with the highest multivariate validity and utility for job performance were:

- GMA plus a work sample test (mean validity of .63)
- GMA plus an integrity test (mean validity of .65)
- GMA plus a structured interview (mean validity of .63)

A further advantage of the latter two combinations is that they can be used for both entry level selection and selection of experienced employees. The practical utility implications of these summary findings are substantial. The implications of these research findings for the development of theories of job performance are discussed.”

Appendix 1 gives a description of the measures. It will be seen that the only items in Table 1 that are not at self-evaluated, at least to some extent, are 1, 12 and 16. They are therefore to be included in in the author’s evaluation method.

Serial Number	Measure	Validity r
1	GMA tests	0.51
2	Work sample tests	0.54
3	Integrity tests	0.41
4	Conscientiousness tests	0.31
5	Employment interviews (structured)	0.51
6	Employment interviews (unstructured)	0.38
7	Job knowledge tests	0.48
8	Job try-out procedure	0.44
9	Peer ratings	0.49
10	T & E behavioural consistency method	0.45
11	Reference checks	0.26
12	Job experience (years)	0.18
13	Biographical data measures	0.35
14	Assessment centres	0.37
15	T & E point method	0.11
16	Years of Education	0.10
17	Interests	0.10
18	Graphology	0.02
19	Age	-0.01

Table 4.1: From the paper by Schmidt and Hunter, showing 19 Personality Tests and their Correlation with Job Performance

4.8 What is missing from the Schmidt and Hunter research: Health

It goes almost without saying that employees' health and fitness must be at a certain minimum level to be able to perform the work assigned to them. This is recognised in most companies today and no further research is necessary to confirm this fact. It is also generally non-falsifiable, at least if competent medical authorities eliminate malingering. It will therefore also be included in the author's index of Human Capital.

4.9 A Current Attempt at Human Capital Management: The Human Capital Revenue Factor

Sales per Employee is one of the oldest measures that at least hint at human capital measurement. But this measure fails if many of the employees are contract workers and not on the payroll. Other workers are part-time. This leads to the concept of FTE, or Full Time Equivalent. For example, ten part-time workers working one half-day each are equivalent to five full-time workers, or five FTE's. This is once again, a Fitz-Enz innovation. There have been few others.

4.10 Chapter 4: Conclusion

This chapter emphasised the importance of Schmidt and Hunter's work in emphasising the importance of intelligence as a component of human capital evaluation. Experience and Qualifications are also emphasised. What is missing from the Schmidt and Hunter evaluation is any mention of employee Health, which was presumably presupposed in their investigations. In the South African context particularly, Health must be considered because of the prevalence of diseases such as HIV in the work place. Health and the other three chosen indices of IQ, Experience and Qualifications are discussed more detail in the next chapter.

Chapter 5: The Two sides of Human Capital Evaluation

5.1 Chapter 5: Overview

This chapter can be condensed into the statement: The Value of a Company's Human Capital, or, What You got for Your Money. The components which make up the total value must be "hard" measures, that is expressed in numbers, reproducible and accurate. (And therefore, acceptable to accountants, engineers and other numerate professions). The author's research has revealed only four measures which meet these criteria. They are: employee qualifications, experience, health and IQ. Of these four, the only contentious one is IQ, which is discussed in detail as are IQ's correlations with other aspects of the human psyche such as leadership, conscientiousness and the like. Also discussed in detail is the currently popular concept of EQ or emotional intelligence, which is shown to be a much less successful predictor of performance than IQ.

5.2 The Value of a Company's Human Capital: What you got for your money

Certain criteria must be established for the inclusion of any factors in the Human Capital portfolio. These should as far as possible be "hard" measures. Hard being defined as measures which can be compared to conventional accounting measures. They must therefore be reproducible and must not be self -administered. The author's research has revealed only four measures which meet these criteria. They are:

- Employee qualifications
- Employee experience
- Employee health
- Employee IQ

Confirmation of three of these measures is given by Nobel Laureate Gary Becker: "Education, Training and Health are the most important investments in Human Capital." Becker (1993)

Of the four criteria, only the fourth one is controversial. As such it will be discussed first.

5.3 A History of Intelligence Testing

5.3.1 Intelligence Quotient, or IQ

"An intelligence quotient (IQ) is a total score derived from several standardized tests designed to assess human intelligence. The abbreviation "IQ" was coined by the psychologist William

Stern for the German term *Intelligenzquotient*, his term for a scoring method for intelligence tests at University of Breslau he advocated in a 1912 book. Historically, IQ is a score obtained by dividing a person's mental age score, obtained by administering an intelligence test, by the person's chronological age, both expressed in terms of years and months. The resulting fraction is multiplied by 100 to obtain the IQ score." (Wikipedia, 2020).

This reference from Wikipedia related to the original use of IQ tests to measure the intelligence of children. For example, a child of ten who was as intelligent as the average child of 14 would have an IQ of 140: (14/10) x 100 = 140.

These days IQ is often described as the percentile from the mean, with the mean being set as 100. The distribution is assumed to be normal and to have a standard deviation of 15. The horizontal scale runs from 40 to 160. IQs above 160, which are often quoted in popular sources are suspect as they are effectively off the scale.

The fact that we have said that the distribution is assumed to be normal is a valid assumption that has been proved in experiments in the past. Many human characteristics are normally distributed – height and mass are but two examples.

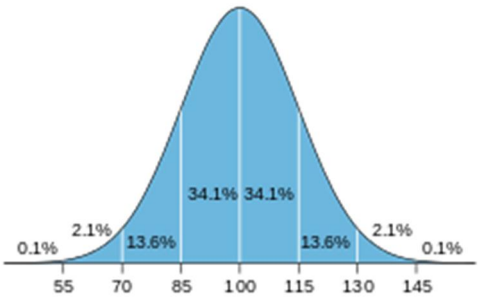

Figure 5.1: Normalized IQ distribution with mean 100 and standard deviation 15.

Various persons have refined the practice of intelligence measurement over the years. The English statistician and polymath Sir Francis Galton made the first attempt at creating a standardized test for rating a person's intelligence.

His work was developed further by French psychologist Alfred Binet who was one of the key developers of what later became known as the Stanford–Binet test. This came about when American psychologist Lewis Terman at Stanford University revised Binet's work, which resulted in the Stanford-Binet Intelligence Scales in 1916. The Stanford Binet became the most popular test in the United States for decades thereafter. The test is still in use, as the Stanford–Binet Intelligence Scale, now in its fifth edition (SB5) and released in 2003. It is a cognitive ability and intelligence test that is mainly used to diagnose developmental or intellectual deficiencies in young children. The test measures five weighted factors and

consists of both verbal and nonverbal subtests. The five factors being tested are knowledge, quantitative reasoning, visual-spatial processing, working memory, and fluid reasoning.

The many different kinds of IQ tests include a wide variety of item content. Some test items are visual, while many are verbal. Test items vary from being based on abstract-reasoning problems to concentrating on arithmetic, vocabulary, or general knowledge.

5.3.2 The g Factor

The British psychologist **Charles Spearman** in 1904 made the first formal factor analysis of correlations between the tests. He observed that children's school grades across seemingly unrelated school subjects were positively correlated and reasoned that these correlations reflected the influence of an underlying general mental ability that entered into performance on all kinds of mental tests. He suggested that all mental performance could be conceptualized in terms of a single general ability factor and a large number of narrow task-specific ability factors. Spearman named it ***g*** for "general factor" and labeled the specific factors or abilities for specific tasks *s*. In any collection of test items that make up an IQ test, the score that best measures *g* is the composite score that has the highest correlations with all the item scores. Typically, the "***g*-**loaded" composite score of an IQ test battery appears to involve a common strength in abstract reasoning across the test's item content. Therefore, Spearman and others have regarded the ***g factor*** as closely related to the essence of human intelligence. This is still the commonly held view today.

Described in other terms we might say that someone who is good at mathematics will also be good at languages, not necessarily to the same extent, but with the score of a numeracy test and the score of a literacy test correlated.

Intelligence testing came to the fore in World War 1 when it began to be used by the US Military. 1.75 million soldiers were tested, using tests based on Binet's work. After the war, positive publicity promoted by army psychologists helped to make psychology a respected field. Subsequently, there was an increase in jobs and funding in psychology in the United States. Group intelligence tests were developed and became widely used in schools and industry.

5.3.3 The Progressive Matrices of John Raven

In 1936, John C Raven developed his Progressive Matrices, one of which is shown below from a 60-item set. All the questions consist of visual geometric designs with a missing piece. The test taker is given six to eight choices to pick from and fill in the missing piece, as shown in the example below.

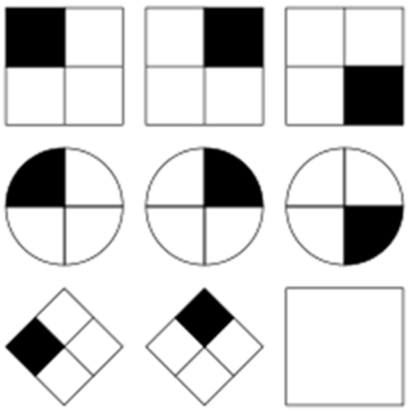

Figure 5.2: An example from the Raven's IQ test

There are various versions of the test such as Advanced Progressive Matrices (APM), Standard Progressive Matrices (SPM) and Standard Progressive Matrices Plus (SPMP).

The Raven's Test is acceptable as an entry test to at least three of the "High Intelligence Societies" viz Mensa, the High IQ Society and the Triple Nine Society. These societies have different entry levels. Mensa has an entry level corresponding to the top 2% of a Western population, in other words above the 98th percentile, which corresponds to an IQ of 130, when the Standard Deviation of the distribution is set at 15. The Triple Nine Society requires an IQ of 146, when the Standard Deviation is 15, depending on the test used, with Ravens APM and Stanford-Binet included.

For our purposes Raven's is a very good test. As described by Robert W. Motta and Jamie M. Joseph, in the Handbook of Psychological Assessment (Third Edition), 2000: The test was introduced in 1938 and has gone through many revisions. Because it is nonverbal, and in most situations requires little more than having the examinee point to the correct item, it is often used in situations where examiners ***want a measure of ability that is not biased by educational background or by cultural or linguistic deficiencies.*** All of the test items are composed of geometric figures that require the test taker to select among a series of designs the one that most accurately represents or resembles the one shown in the stimulus material. The test items are presented in graded levels of difficulty and there are test booklets for different age levels. Validity measures involving the correlation of the Raven Matrices with the Stanford-Binet and the Wechsler Scales range from .54 to .86. The authors indicate that "the scales can be described as 'tests of observation and clear thinking…By themselves they are not tests of 'general intelligence'…They should be used in conjunction with a vocabulary test." Despite this caution, the Progressive Matrices have been viewed as measures of intelligence and have been widely used in many countries to test military groups because they are considered to be independent of prior learning.

Marshalek et al (1983) contended that Raven's was fundamental to general intelligence, ie to ***g,*** because it is:

- one of the most complex tasks to execute, as it draws substantially upon
- executive assembly and control processes that structure and analyse the problem,
- assemble a strategy of attack on it,
- monitor the performance process, and
- adapt these strategies as performance proceeds…"
- it is also culture free, a valuable characteristic in multicultural countries like South Africa.

As with all IQ evaluations, there are detractors and champions for each type. For our purposes, Raven's matrices are the best choice not only because of their applicability, by also for their ease of application and particularly for their non-cultural nature.

5.3.4 Wechsler and Stanford-Binet

David Wechsler produced the first version of his test in 1939. It gradually became more popular and overtook the **Stanford-Binet** in the 1960s. It has been revised several times, as is common for IQ tests, to incorporate new research. One explanation is that psychologists and educators wanted more information than the single score from the Binet. Wechsler's ten or more subtests provided this. Another is that the Stanford-Binet test reflected mostly verbal abilities, while the Wechsler test also reflected nonverbal abilities. It is currently in its fourth edition (*WAIS-IV*) and was released in 2008. It is the most widely used IQ test, for both adults and older adolescents, in the world. Data collection for the next version (*WAIS 5*) began in 2016 and is projected to be complete in 2019. There are different versions of the Wechsler test. There is the Wechsler Intelligence Scale for Children (WISC) and the Wechsler Adult Intelligence Scale (WAIS). Both have several versions.

The Stanford-Binet has also been revised several times and is now similar to the Wechsler in several aspects, but the Wechsler continues to be the most popular test in the United States at the present time.

5.3.5 Raymond Cattell

Raymond Cattell (1941) proposed two types of cognitive abilities in a revision of Spearman's concept of general intelligence. Fluid intelligence (Gf) was hypothesized as the ability to solve novel problems by using reasoning, and crystallized intelligence (Gc) was hypothesized as a knowledge-based ability that was very dependent on education and experience. In addition,

fluid intelligence was hypothesized to decline with age, while crystallized intelligence was largely resistant to the effects of aging.

Hence, we see that there is a variety of individually administered IQ tests in use in the English-speaking world today. The most commonly used is the Wechsler Adult Intelligence Scale for Adults. Other commonly used individual IQ tests include the current versions of the Stanford-Binet Intelligence Scales and Raven's Progressive Matrices.

5.3.6 The Importance of Intelligence in a Business Environment

The basic premise of this study is that superior intelligence produces superior results. But it must be stressed, this is a statistical assessment. Persons of superior intelligence *usually* perform better in any defined situation, but this is a statistical fact, subject to statistical error. The writer will confess that, although he is a person of at least moderate intelligence, he has sometimes in his long work career, made some very stupid decisions. In assessing this fact, these decisions were sometimes the result of not thinking the problem through, and of making a snap decision. On the other hand, sometimes his snap decisions have yielded excellent outcomes, as the pressure to make the decision sharpens the intellect apparently! This is an area which requires additional research: The relation between time pressure and other factors on decision-making ability. It is not pursued further in this study.

5.3.7 Knowledge, Understanding and Wisdom

The Bible is a source of help here. In the book of Proverbs, the writer encourages his reader to get three related things: Knowledge, (Proverbs, 40 verses), Understanding and Wisdom. (Proverbs 1:5, 4:5, 4:7, 16:16, 17:16) This seems to apply generally in life, not just in religious matters. Knowledge is the basic requirement – without knowledge of a situation, nothing is possible. But the knowledge one acquires must be *understood.* The writer can testify to the fact that as an undergraduate, he was able to pass at least one subject on knowledge alone, without understanding. Only on being re-presented with the subject at graduate level did the *understanding* come. "So that is why this or that was emphasised! I *understand* it now." But understanding does not mean wisdom has arrived. Wisdom is acquired through experience and mistakes. Wisdom allows one to use the knowledge that he has acquired and that he understands. And wisdom is many facetted – not only wisdom regarding say the operation of a mechanical system, but the ability to interact positively with the human components of the system.

Knowledge, understanding and wisdom are all components of intelligence, and at least a certain level of intelligence is necessary to perform any task. But when it comes to superior intelligence, there is a human problem which presents itself. There is something intimidating

about superior intelligence, more, it would seem, than there is about beauty, strength or sporting prowess.

That there is considerable controversy around IQ is a given. Various authors have contributed to this controversy by the accusations made in their publications, where it is claimed that there are racial and to a lesser extent, gender implications in the measurement of IQ. Examples of such are Jensen (1969), Herrnstein, R.J. & Murray, C., (1996), Hans Eysenck (1981) and Nobel Prize winner William Shockley (1992).

As far as the veracity or otherwise of the claims of these authors, it remains a truth, that IQ is both a reliable, reproducible, measurable human characteristic. It is not self-administered and remains a constant (but in some forms it decreases with age) for any individual. It is known to be an important factor in the ability to perform work, and hence is a factor which cannot be ignored in any human reliability evaluation.

5.4 Correlations with IQ

Another reason for including IQ in the human capital portfolio is that it is also a remarkable predictor of other positive human characteristics, which are not so easily measurable. IQ is therefore not only a hard measure, consistent, reproducible and not self-administered, but it also correlates with other, less hard but well-established measures. These include:

- Leadership
- School achievement
- Lifespan
- Workplace performance
- Work-related learning
- Creativity
- Musical creativity
- Patents
- Inventiveness

The correlations for some of these are greater than for others, but they are all consistently positive. These factors will be discussed in turn below. Other correlations with IQ include a positive correlation with political liberalism. There also seems to be a negative correlation between IQ and religious belief. These two last correlations are not germane to our study and will not be considered further.

Some physical attributes are correlated with IQ as well. The best-known example is the amazing correlation between IQ and height! Taller persons have higher IQs with a correlation of 0.2 (Tanner, 1966).

5.4.1 IQ and Leadership

Judge, Ilies and Colbert (2004) in their review of literature on this subject, show that the correlations claimed can be as high as 0.50, as in Lord, De Vader & Alliger (1986). Lower values such as 0.27 are also mentioned. This study cites 96 references from which the authors' conclusions are drawn. In any event the evidence confirms that there is a significant positive correlation between IQ and leadership ability. This gives the lie to a popular misconception that highly intelligent persons cannot communicate with subordinates. It is true however that above a certain IQ, which may be termed usable IQ, the highly intelligent split into two groups – those who can lead, e.g., Bill Gates, with a reported IQ of 150 and those who are hopeless at human relations e.g., Bobby Fischer, the former World Chess champion. There seems to be a general consensus that an IQ of 135, which is just above entry level into the Mensa society, is about the practical limit of generally usable IQ (Zietsman, 2008).

What also emerges in popular culture is that there is a so-called IQ Gap of about 30 points, which, if it is exceeded, leads to communication difficulties between a leader and the led group. This is because the leader sometimes cannot understand why the followers cannot "get the point" and the followers on their part, cannot understand the leader. Common experience seems to confirm this, but there has not been much academic research to prove it.

Of importance to the present study is the implications of this concept of IQ Gap for organisational design. One should ensure an IQ gap of not more than say 20 to 30 points between a group leader and the average IQ of the group. This can apply from board level down, so we could postulate an IQ structure in a company:

Board

Top Management

Middle Management

Front Line Management

Workforce

The above pyramid considers only the IQ of the management at various levels but is an interesting concept to speculate on. If for example we take the practical limit of IQ as 130 for good communication and assign this to the Board members and reduce this by five points for each level we arrive at the following:

Board: 130

Top Management: 125

Middle Management: 120

Front Line Management 110

Workforce 100

To obtain a university degree in engineering, pre-1994 in South Africa, required an IQ of 125 (Zietsman, 2000). This correlates well with our Top Management level which in an engineering company would be probably consist of graduate engineers in design, maintenance and similar portfolios, together with professionals of similar IQ in other fields.

Middle Management with an IQ of 120 is simply the result of our arbitrary 5-point difference in IQ at the various levels. The result however is the relatively high IQ for Frontline Managers of 110, which is higher than the average for a European or North American population. What also follows is the high value of 100 for the workforce – just on the Western Average and usually correlated with the ability to complete high school in Europe or North America.

What is attractive about such a high-IQ organisation is that there is no problem for the Board members in communicating with the workforce. The 30-point IQ barrier communication barrier has not been breached. What is necessary however is to ensure the 100-point IQ level for the workforce.

5.4.2 IQ and Scholastic Achievement

We would expect a positive correlation here, but there are also caveats. The highly intelligent are bored by school life and often do poorly scholastically, only remaining in school because it is a legal requirement until a certain age, which differs from country to country. Furthermore, highly intelligent people are frustrated even by the pace of university learning and so either drop out before completion of a degree or do not bother to even attend university. Examples of this are Bill Gates of Microsoft, who left off studying law at Harvard after one year and James Woods the actor, who studied engineering at MIT, but did not complete his degree.

The SAT scores for university entrance in the USA is strongly correlated with IQ and IQ estimates for university entrants are therefore easily obtained. According the SAT correlation, Gates' IQ is 150 and Woods' is quoted in various sources as over 180. IQs of 180 are suspect however as according to standardised IQ measures such as the Stanford-Binet, the measurable scale only reads from 40 to 160, with a midpoint of 100. Nevertheless, Wood scored 800 out of 800 on the literacy part of the SAT and 799 out of 800 on the numeracy part of the test.

5.4.3 IQ and Gender

For the sake of completeness, some mention must be made of any differences, supposed or real in the IQ of males versus females. One good summary of this topic is provided by Chandra, R and Azimmudin, S (2013) where they quote from another source as follows:

"Alan Feingold (1992) focused on male-female differences in average performance and observed that males score higher than females on tests of general knowledge and mechanical reasoning and females scored higher than males on tests of language usage. There were no notable sex differences in general verbal ability, abstract reasoning or memory span."

5.4.4 IQ and Creativity

Jauk, et al (2013) in their research on the link between creativity and intelligence, have the following to say:

"The relationship between intelligence and creativity has been subject to empirical research for decades. Nevertheless, there is yet no consensus on how these constructs are related. One of the most prominent notions concerning the interplay between intelligence and creativity is the ***threshold hypothesis***, which assumes that above-average intelligence represents a necessary condition for high-level creativity. While earlier research mostly supported the threshold hypothesis, it has come under fire in recent investigations. The threshold hypothesis is commonly investigated by splitting a sample at a given threshold (e.g., at 120 IQ points) and estimating separate correlations for lower and upper IQ ranges. However, there is no compelling reason why the threshold should be fixed at an IQ of 120, and to date, no attempts have been made to detect the threshold empirically. Therefore, this study examined the relationship between intelligence and different indicators of creative potential and of creative achievement by means of segmented regression analysis in a sample of 297 participants. Segmented regression allows for the detection of a threshold in continuous data by means of iterative computational algorithms. We found thresholds only for measures of ***creative potential*** but not for ***creative achievement***. For the former the thresholds varied as a function of criteria: When investigating a liberal criterion of ideational originality (i.e., two original ideas), a threshold was detected at around 100 IQ points. In contrast, a threshold of 120 IQ points emerged when the criterion was more demanding (i.e., many original ideas). Moreover, an IQ of around 85 IQ points was found to form the threshold for a purely quantitative measure of creative potential (i.e., ideational fluency). These results confirm the threshold hypothesis for qualitative indicators of creative potential and may explain some of the observed discrepancies in previous research. In addition, we obtained evidence that once the intelligence threshold is met, personality factors become more predictive for creativity.

On the contrary, no threshold was found for creative achievement, i.e., ***creative achievement*** benefits from higher intelligence even at fairly high levels of intellectual ability." So, the most recent research shows that there is a relationship between intelligence and creativity.

5.5 Other Issues: So-called Emotional Intelligence

In this century there has been much literature generated in an attempt to either discredit IQ or offer alternatives to it. One such popular genre of literature has had Emotional Intelligence, or EQ offered as not only an alternative to IQ, but something that is superior to it. People will often say, defensively, that they are not concerned with IQ. If one does not have high EQ, intelligence is useless.

Emotional Intelligence was developed by Goleman (1995) in the book of the same name. It was to some extent in this author's opinion, a "flavour of the month" or more accurately a flavour of a decade. It is of little interest in our study as the EQ value for any individual is self-generated by answering a questionnaire.

Jordan B Peterson, a psychology professor at the University of Toronto and clinical psychologist, is quoted on the website Quora, as follows. He is particularly opposed to EQ and conversely is a champion of IQ:

"There is no such thing as an Emotional Intelligence Quotient. Let me repeat that: "*There is no such thing as an EQ.* "The idea was popularized by a ***journalist***, Daniel Goleman, not a ***psychologist*.** You can't just invent a trait. You have to define it and measure it and distinguish it from other traits and use it to predict the important ways that people vary.

"EQ is not a psychometrically valid concept. Insofar as it is anything (which it isn't), it's the Big Five trait, Agreeableness. Agreeable people are compassionate and polite, but they can also be pushovers. Disagreeable people, on average (if they aren't too disagreeable) make better managers, because they are straightforward, don't avoid conflict and cannot be easily manipulated.

"Let me say it again: *There is no such thing as an EQ*. Scientifically, it's fraudulent.

"IQ is a different story. It is the most well-validated concept in the social sciences, bar none. It is an excellent predictor of academic performance, creativity, ability to abstract, processing speed, learning ability and general life success.

"Other traits are essential to overall success, including conscientiousness, which is an excellent predictor of grades, managerial and administrative ability, and life outcomes, on the more conservative side.

“There is nothing that will provide you with a bigger advantage in life than a high IQ. Nothing.

“It might be objected that we cannot measure traits such as conscientiousness as well as we measure IQ, as we primarily rely on self or other reports for the former. But no one has solved this problem. There are no “ability” tests for conscientiousness. I am speaking as someone who has tried to produce such tests for ten years, and failed (despite trying dozens of good ideas, with top students working on the problem). IQ is king. This is why academic psychologists almost never measure it. If you measure it along with your putatively “new” measure, IQ will kill your ambitions. For the career minded, this is a no-go zone. So, people prefer to talk about multiple bits of intelligence and EQ and all these things that do not exist.”

(Inc: https://www.inc.com/quora/its-time-to-stop-talking-about-eq-because-it-doesnt-actually-exist.html)

5.6 The Big Four

And so, we have four measures of human capital that fulfill the criteria that may be accepted by an accounting practice as sufficiently “hard” to be used in comparisons with more traditional forms of capital. These we will call the Big Four. It was hoped to arrive at a Big Five, to tie in with the other big fives in the literature e.g., the Big Five Personality Traits and in popular South African parlance, the Big Five game animals that even appeared on our currency. But only the previously mentioned four parameters of Health, Qualifications, Education and Intelligence were found to be sufficiently robust to be included in our human capital calculations. In summary then, we have what we paid for the human capital, derived from a discounted cash flow calculation and what we got for our money, so to speak viz the four factors of Qualifications, Intelligence, Health and Experience. The author’s research has not revealed any other measures that stand up to the reproducibility and other criteria demanded by the conventions of accounting. All other popularly quoted measures are defective, usually in that they are self-evaluated. This includes the presently much vaunted Emotional Intelligence test, referred to above, which is actually a rehash of various personality tests and is being increasingly discredited.

5.7 Chapter 5: Conclusion

So, we are left with only four hard measures to determine the ***value*** of the human capital of the firm. It is nevertheless necessary to discuss some of the soft measures, because of their popularity and to discredit them for our purposes. This is done in the next chapter.

Chapter 6: Personality

6.1 Chapter 6: Overview

Personality Measures are very popular tools purportedly used in the assessment of employees, but of limited value for our purposes because they are not numerate measures, acceptable to accounting practice. A history of the development of personality measures is given covering the work of authorities such as Galton, Cattell and Eysenck. This is followed by a detailed evaluation of one of the most popular tests, viz the Myers-Briggs evaluation and the experience of the writer in its use. Also included is a discussion on the Dunning-Kruger effect, which, to put it bluntly, is when persons of lower intelligence over-estimate their intellectual ability. Hence, once again we need hard measures, not personal estimates of one's abilities.

6.2 Personality Measures

Personality measures do not form part of the author's Human Capital index for the previously stated reason that there is no personality measure which is not self-assessed and therefore unreliable as an accounting measure. Nevertheless, because of the importance attached to personality by so many HR professionals, it is necessary to include this information in this dissertation, if for no other reason to deny the received wisdom as to personality measures.

6.3 A Brief History of the more important Personality Measures

6.3.1 Galton

In 1884, Sir Francis Galton (who also involved in early work on the measurement of intelligence), was the first person who is known to have investigated the hypothesis that it is possible to derive a comprehensive taxonomy of human personality traits.

6.3.2 Cattell

In 1940, Raymond Cattell constructed a self-report instrument for the clusters of personality traits he found which he called the Sixteen Personality Factor Questionnaire.

6.3.3 Eysenck

One of the first and most influential developers of personality testing was Hans Eysenck, the German-born English psychologist, who also did work on intelligence. This was described in his 1967 book *Dimensions of Personality*. This initial model of personality was a simple two-

axis description, the two axes being Extroversion/Introversion and Emotional Stability/Instability leading the four personality types:

- Stable Extrovert
- Unstable Extrovert
- Stable Introvert
- Unstable Introvert

Emotionally unstable people are also defined as Neurotic, or in common terms, nervous or highly strung.

A subsequent modification to his model added another axis, Psychoticism. Psychoticism is a personality pattern typified by aggressiveness and interpersonal hostility.

When the above two definitions are used in Eysenck's model it is known as the PEN model of personality. (Psychotic, Extrovert, Neurotic). This terminology only relates to one end of each of the three axes. The opposite end of the psychotic axis is compassionate. The opposite end of the neurotic axis is confident.

The major strength of Eysenck's model was to provide a detailed theory of the causes of personality, which others have built on subsequently.

6.4 The Big Five

The Big Five Personality Traits, also known as the Five Factor Model, or FFM is currently one of the most popular descriptors of personality. It was developed by Lewis Goldberg in the 1980's and developed by McCray and Costa. It also demonstrates how Eysenck's original model has been developed and made more complex over the years. The five factors in the model are

- Openness to Experience (*inventive/curious* vs. *consistent/cautious/dogmatic*).
- Conscientiousness (*efficient/organized* vs. *easy-going/careless*)
- Extroversion (*outgoing/energetic* vs. *solitary/reserved*)
- Agreeableness (*friendly/compassionate* vs. *challenging/detached*)
- Neuroticism (*secure/confident* vs. *sensitive/nervous*)

It will be seen that three of the factors are the same as for Eysenck viz:

- Extrovert/Introvert
- Agreeableness, which is Eysenck's psychotic scale
- Neuroticism, which is Eysenck's stable/unstable scale

While Openness and Conscientiousness are new.

6.5 The Myers-Briggs Test

Apart from the Five Factor Model, concurrent favourite personality test is the Myers-Briggs test, which is based on the following axes of personality. The following description is taken in part, directly from the Wikipedia article on the subject, as indicated by the inverted commas.

- Extroversion/Introversion (E/I)

Extroverted persons learn best by talking and interacting with others. By interacting with the physical world, extroverts can process and make sense of new information. The introverted person prefers quiet reflection and privacy. Information processing occurs for introverts as they explore ideas and concepts internally.

- Sensing/Intuition (S/N) (Notice how N is used here for intuition, rather than I, which has already been used to signify Introversion)

“The second continuum reflects what people focus their attention on. Sensing types enjoy a learning environment in which the material is presented in a detailed and sequential manner. Sensing types often attend to what is occurring in the present and can move to the abstract after they have established a concrete experience. Intuitive types prefer a learning atmosphere in which an emphasis is placed on meaning and associations. Insight is valued higher than careful observation, and ***pattern recognition*** occurs naturally for intuitive types.” This last sentence is significant as pattern recognition is one of the determinants of intelligence, as is discussed elsewhere. So, there may be an implication here – that the Intuitive personality is on average more intelligent than the Sensing personality. There is probably scope for psychological research here, as a link is indicated between intelligence and personality.

- Thinking/Feeling (T/F)

“The third continuum reflects a person's decision preferences. Thinking types desire objective truth and logical principles and are natural at deductive reasoning. Feeling types place an emphasis on issues and causes that can be personalized while they consider other people's motives.”

- Judging/Perceiving (J/P)

“The fourth continuum reflects how a person regards complexity. Judging types will thrive when information is organized and structured, and they will be motivated to complete assignments in order to gain closure. Perceiving types will flourish in a flexible learning environment in which they are stimulated by new and exciting ideas. Judging types like to be on time, while perceiving types may be late and/or procrastinate.”

The Myers-Briggs inventory produces 16 personality types:

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTJ	ESFJ	ENFJ	ENTJ
ESTP	ESFP	ENFP	ENTP

Table 6.1: The 16 Myers-Briggs Personality Types

There has been an attempt by others, outside of the Myers-Briggs ambit, to put names on to these personalities, to make them somewhat more understandable. Research has also been done to assess the relative percentages of each personality type in a nation. Some types are rare, others common. Approximate median values for the percentage of each type are given in the table below, for the United States population:

ISTJ 12.5%	ISFJ 11.5%	INFJ 2%	INTJ 3%
ISTP 5%	ISFP 7%	INFP 4.5%	INTP 4%
ESTJ 10%	ESFJ 11%	ENFJ 3.5%	ENTJ 3.5%
ESTP 4.5%	ESFP 6.5%	ENFP 7%	ENTP 3.5%

Table 6.2: Population Percentages for the 16 Myer-Briggs Types

The Myers-Briggs is popular in business circles but is considered even less reliable than other personality measures. For example, one's personality type can change when one redoes the test after several weeks:

"The interesting – and somewhat alarming – fact about the MBTI is that, despite its popularity, it has been subject to sustained criticism by professional psychologists for over three decades. One problem is that it displays what statisticians call low "test-retest reliability." So, if you retake the test after only a five-week gap, there's around a 50% chance that you will fall into a different personality category compared to the first time you took the test." (Fortune, May 15, 2013)

Hence while it is tempting on the surface to include the Myers-Briggs or other personality assessments into our human capital evaluation, they are of course self-administered

evaluations. This means that one can manipulate the results by second-guessing what the correct response might be to the question being answered.

This is not to say that self-administered tests are not useful at times and can be used by managers and human resources personnel in a variety of ways. When the author and a group of his peers went through the Myers-Briggs process, the results seemed to confirm the general observations of the author as to the strengths and weaknesses of the individuals in the group.

For example, there were only two INTJs in the group, as would be expected, because of the rarity of this personality type. As predicted by Myers and Briggs, these were the group's innovators, the one developing a method whereby a maintenance contractor would be paid according to results, the results being the availability and reliability of the equipment he was to maintain. The other INTJ (the author) was the developer of a programme for the improvement in human reliability of power plant operators, by the means of difficult runs on the powerplant simulators, with penalties and rewards. The other observation which Myers and Briggs would have predicted was that the two INTJs did not get on particularly well with each other, while other personality types were more tolerant of both.

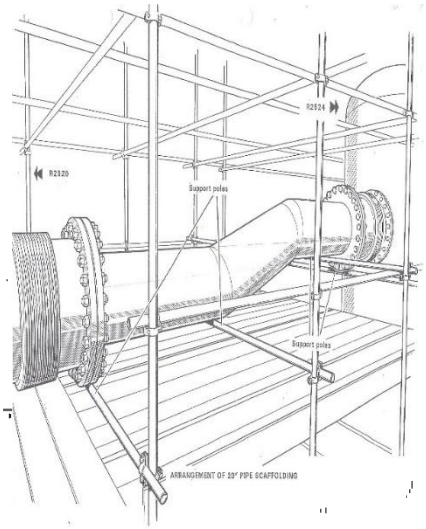

Figure 6.1: Temporary Pipe at the Flixborough Plant (Bradley, 2017)

6.6 The Dunning-Kruger Effect

In such situations, with groups of engineers in design offices or in engineering support groups, Myers-Briggs seems to have value. It might be possible for example to design the group to have a certain number of specific personality types to optimise group performance. For example, it might be necessary to appoint one of the E class personalities as the group leader to ensure effective internal and external communication as to the group's objectives. In other cases, where let it be said the groups are not as professional, intelligent and experienced,

Myers-Briggs can yield inaccurate results. This is due to the Dunning-Kruger effect (1999), where persons of moderate intellectual ability overrate their abilities, whereas persons of higher intelligence tend to underrate theirs. In such cases, self-evaluation results can be misleading and even dangerous and cannot be used.

This effect was brought home to the author when conducting training of a group of oil field operatives in the Middle East. The group consisted of engineers, artisans and operators, all well experienced in their areas of expertise. In a root cause analysis exercise, the group was tasked with investigating the Flixborough Chemical Plant disaster (Bradley, 2017). Figure 6.1 illustrates the cause of the problem – a temporary pipe connection between two vessels. The answer to the problem was that, if a free body diagram of a temporary pipe, with a dogleg in the middle and bellows at either end, was analysed, the pipe would be seen to lift off its two of its supports under the normal operating pressure in the system. It would pivot about the pipe support in the left of the picture. This would lead to the tearing of both the bellows and the release of highly inflammable gas, which, combined with an ignition source, would cause the enormous explosion that destroyed the plant. All members of the group accepted the analysis except for one of the operators, who was scathing in his criticism of the solution and of the trainer. “The pipe is heavy, it cannot lift” was the full extent of his argument. This person was so adamant in the correctness of his position that he requested that the course never be presented again with the present trainer.

The point to be made here is that such a person would almost certainly overestimate his abilities if given the chance in a personality evaluation. And therefore, personality evaluations such as the Big Five or the Myers-Briggs cannot be included in any measure of human capital that is to stand up to accounting levels of scrutiny. It may however be useful as internal measure in a high-IQ engineering group or other professional group, to assist in the design of the composition of such a group.

6.7 Chapter 6: Conclusion

This chapter hopefully helps to convince the reader of the unreliability of Personality Assessments. For example, the popular Myers-Briggs personality inventory has a test-retest reliability of only 50%. This means that in a retest after a period as short as five weeks, the result might indicate a different personality. Even more serious in the writer’s opinion is the Dunning-Kruger effect where less intelligent employees over-estimate their intellectual ability. This serves as another warning against self-administered tests.

Chapter 7: Other Measures of Human Capital

7.1 Chapter 7: Overview

Having hopefully convinced the reader that the value of a firm's human capital can be best expressed using the four parameters IQ, Health, Experience and Qualifications, this chapter describes the process of developing these four into a composite index. Discussed are questions like whether the four parameters should have equal weight, what the limiting values of the index should be and questions of linearity of the scales.

Experience is one of the parameters where the number of years of experience does not add the same degree of value year upon year. Here the work of Henderson on Learning Curves is discussed and a log scale is chosen for experience.

Ordinality vs Cardinality is another factor which is considered as is whether the combined index should be additive or multiplicative.

7.2 Health

Employee health is fairly obviously a factor of importance to a company. Sick employees are not productive. They make mistakes, work slowly, take time off and might infect other workers with their illnesses. Apart from these truisms, the effects of poor employee health can be measured and documented. Japsen (2012) describes how poor employee health costs the US economy $576 billion annually. In 2012 the Gross Domestic Product (GDP) of the USA was $16.16 trillion, so employee health problems are about 3.6% of GDP, a significant amount. Using our previous analogy of what on average affects a nation's economy, also affects individual companies, it might be said that on average employee ill health costs a company about 3.6% of its turnover per year.

A ready-made health index is the Vitality Index as demonstrated below. The Vitality system is part of the South African Discovery Health medical aid company and is used in this treatise as it fits the purpose and is readily available at Discovery clinics throughout South Africa.

2019 VITALITY HEALTH CHECK RANGES					
Metric	Blood glucose*	Blood pressure	Cholesterol*	Weight Assessment	Smoker status
In-range	< 7.8mmol/L	< 130/80mmHg	< 5mmol/L	18.5 ≤ BMI < 25	Non-smoker for at least the past 12 months
Intermediate risk	7.8mmol/L ≤ blood glucose < 11mmol/L	130/80mmHg ≤ blood pressure < 160/100mmHg	5mmol/L ≤ total cholesterol < 7.5mmol/L	BMI < 18.5 or 25 ≤ BMI < 30	n/a
High risk	≥ 11mmol/L	≥ 160/100mmHg	≥ 7.5 mmol/L	BMI ≥ 30	Smoker

Table 7.1: Vitality Health Check Methodology

If a member's waist circumference is less than 80cm for females or 94cm for males; a BMI result that is between 25 and 30 will be classified as in-range, and a BMI result of 30 or higher will be classified as intermediate risk.

Where Lipogram results and total cholesterol results are available, the better result of the two tests will be used. An LDL cholesterol result is in range if less than 3mmol/L, and high-risk if greater than 5mmol/L.

Where HbA1c results are available these results will be used instead of blood glucose. An HbA1c result is in-range if less than 6%, and high risk if greater than or equal to 7%.

BMI (body mass index) is a measure of your nutritional status and also an indicator of the possible risk that your weight may have on your future health. It is defined as a person's weight in kilograms divided by the square of the person's height in metres (kg/m^2)

BMI	NUTRITIONAL STATUS
Below 18.5	Underweight
18.5 – 24.9	Normal Weight
25.0 – 29.9	Overweight
> 30	Obese

Table 7.2: Body Mass Index (BMI)

The Health Index is non-continuous and can have values of 3, 6 or 9 for each individual. This is based on the Vitality Health rating as determined at any Vitality Health clinic in the country.

7.3 Experience and the Learning Curve

The experience that an employee has increases his value to the firm as the years of experience increase. This happens with all the employees and so the company tends to do better with the passage of time. This is a verifiable phenomenon, known as the learning curve. It is so well established that military contracts in the USA are often based on learning curves. The unit price for a new tank, for example, will be based on a certain production run. For a percentage of units in early manufacture, the items will be made at a loss, profit only being accrued after a certain number of units have been made.

Generally, the production of any good or service shows the experience curve effect, also known as the learning curve effect. Each time cumulative volume doubles, value added costs (including administration, marketing, distribution, and manufacturing) fall by a constant percentage.

Wikipedia has the following description of the effect:
(https://en.wikipedia.org/wiki/Experience_curve_effects):

“The Experience Curve was developed by Bruce D. Henderson and the Boston Consulting Group (BCG) while analysing overall cost behaviour in the 1960s. In 1968, Henderson and BCG began to emphasize the implications of the experience curve for strategy. Research by BCG in the 1960s and 70s observed experience curve effects for various industries that ranged from 10 to 25 percent.

These effects are often expressed graphically. The curve is plotted with the cumulative units produced on the horizontal axis and unit cost on the vertical axis. A curve showing a 15% cost reduction for every doubling of output is called an “85% experience curve”, indicating that unit costs drop to 85% of their original level.

The experience curve is described by a power-law function sometimes referred to as **Henderson's Law**:

$$C_n = C_1 n^{-a}$$

where:

- C_1 is the cost of the first unit of production
- C_n is the cost of the n-th unit of production
- n is the cumulative volume of production
- a is the elasticity of cost with regard to output

This effect is very powerful. Take for example the following case:

- C_1 = R 100
- C_n is the cost of the n-th unit of production
- n = 1000
- a = 0.15, (for an 85% learning curve)

Then C_n = 35.48

The Learning Curve, as expressed above, is very relevant to a company manufacturing product in batches, as opposed to mass production on assembly lines.
NASA research indicates the values for the following experience curves:

- Aerospace 85%
- Shipbuilding 80-85%
- Complex machine tools for new models 75-85%
- Repetitive electronics manufacturing 90-95%
- Repetitive machining or punch-press operations 90-95%
- Repetitive electrical operations 75-85%
- Repetitive welding operations 90%
- Raw materials 93-96%
- Purchased Parts 85-88%

The effect of this is also known locally. In discussion with the management of a specialist car company in the Eastern Cape, the power of the learning curve was demonstrated. This company had priced a car to a customer on the basis of a run of several hundred, knowing it would lose money on the first few dozen cars, but recoup the loss as the production increased. The customer then cancelled the contract after five cars were produced. This caused the bankruptcy of the specialist car maker.

The implications of learning curves for our study are that employee turnover is bad as it pushes the company back up the learning curve.

7.4 Qualifications

This measure is simple to calculate, using the SAQA index, as derived by the South African Qualifications Authority, which awards a number from 1 to 10. For example, the highest possible number, 10, corresponds to a PhD qualification. Appendix 3 gives details of the SAQA system.

7.5 Combining the Four Indices into a Composite Index

Our overall assessment of the company's human capital is in effect a Key Performance Indicator, or KPI.

The International Vocational and Training Association (IVETA) (http://www.iveta.org) provides the following summary of the research of others in this area:

- Sparse: The fewer KPIs the better.
- Drillable: Users can drill into detail.
- Simple: Users understand the KPI.
- Actionable: Users know how to affect outcomes.
- Owned: KPIs have an owner.
- Referenced: Users can view origins and context.
- Correlated: KPIs drive desired outcomes.
- Balanced: KPIs consist of both financial and non-financial metrics.
- Aligned: KPIs do not undermine each other.
- Validated: Workers cannot circumvent the KPIs

Our proposed index, which is to be used by top management, does in fact agree with all the above, when used by top management. The final point on the list is especially important to us and is the very reason the components of our KPI have been chosen: they are hard measures and cannot be interfered with by the employees.

We now have to consider the index that will be used to indicate what a company got for its investment in its human capital. Questions to be asked are:

- Are the four measures to be given equal weight?
- Is the index an ordinal or a cardinal number, i.e., does it merely say that value of 4 say, is better than a value of 2, without being able to quantify the difference, or does 4 mean twice as good as 2?
- Can the values for the four measures be reasonably multiplied together, to derive the index, or should some other form of conjugation be used?

7.6 Equal Weighting

Equal weighting obviously implies that all four measures have an equal effect on the organisation, be that effect good or bad. In other words, do employee health, experience, qualifications and IQ contribute equally to the performance of the organisation? One way in which this could be measured is the effect on the organisation in monetary terms. It has been said elsewhere in this document that employee ill health costs the US economy millions of

dollars in lost production. But it is not as easy to quantify the effects of the other three measures.

As a first approximation, it is decided that the measures will have equal weight until further research reveals that a better solution is possible. Some other established indices will now be discussed to see how others have used indices and what their characteristics are.

7.7 Overall Equipment Effectiveness (OEE)

The Overall Equipment Effectiveness index was developed in Japan by the Japan Institute of Plant Maintenance and is widely used as a Key Performance Indicator, or KPI to assess the degree of excellence in industrial plant operation and maintenance. It consists of three factors, all numbers between zero and unity:

- Quality
- Performance
- Availability

There is even a website devoted to this KPI alone. (https//www.oee.com). This website states:

"OEE (Overall Equipment Effectiveness) is the gold standard for measuring manufacturing productivity. Simply put – it identifies the percentage of manufacturing time that is truly productive. An OEE score of 100% means you are manufacturing only Good Parts, as fast as possible, with no Stop Time. In the language of OEE that means 100% Quality (only Good Parts), 100% Performance (as fast as possible), and 100% Availability (no Stop Time)."

This simple formula implies several things. For example, it implies that the three components of the index have equal weight. This is a good first approximation but achieving unity or 100% in all three measures is not necessarily possible.

7.8 Lusser's Product Rule

Another example is Lusser's Product Rule (Bradley, p 29). This was first formulated in WW2 by Robert Lusser in the development of the V1 flying bomb, effectively to world's first cruise missile, to use modern parlance. It states that any subsystem of a device, that can cause the device to fail, is in series, mathematically, with all similar subsystems. Hence the reliability of all such systems must be multiplied together to determine the reliability of the device

It is proposed that our overall index should be somewhat similar, but first we must investigate other options to the simple product rule as given above. For example, should the indices be added together, rather than multiplied?

7.9 Ordinality vs Cardinality

To have an index that is cardinal is obviously better than an ordinal one. If the index is ordinal, it merely indicates that one company is better than another, but not by how much, whereas a cardinal index states that one company is a certain percentage better than another. Cardinality is not always possible. For example, techniques such as Failure Modes and Effects Analysis, used to assess the reliability of engineering designs will estimate three numbers for probability of occurrence, seriousness of failure and ease of detection on an ordinal basis. These numbers are then multiplied together to get a Risk Index. Statisticians are against the practice, while engineers use the technique in the absence of anything better. Of the four measures that make up our index, the following applies:

- Employee health. This measure will be a value equal to 100% or less. A figure of 81% for example will indicate that 19% of the workforce have substandard health, according to the metrics used, as discussed elsewhere. This is a cardinal measure. 100 is 19% better than 81.
- Experience, measured in years. Although it can be argued that one person's experience is better than another's because they learn faster and retain more, for our purposes, the first thought is to assume a linear relationship between improvement in performance and years of experience. This however goes against the theory of the learning curve, discussed elsewhere, which assumes a law of diminishing returns with years of experience. For the purposes of classification, we will use the simple linear expression, for example, that ten years' average experience is better than five years of experience. This will probably over-rate the effect of experience in the organisation, but it is not possible at this time to assess the learning curve effect when comparing two organisations, both with people at all stages of their own learning curves.

  For the present purposes therefore, we will assume the linear relationship. This being the case, years of experience is assumed to be cardinal and hence can contribute meaningfully to our index.

- Qualifications. In the South African context, qualifications are rated by SAQA, the Southern African Qualifications Authority and are expressed as a number depending on the qualification. For example, a PhD rates as 10, a master's degree as 9, etc. These numbers are probably ordinal, as the process by which they have been derived is not known. An assumption could be made as to their cardinality in the first instance eg a PhD is worth 10% more than a master's degree on the SAQA system.

- IQ. There is definitely a cardinality about IQ numbers, and it is highly non-linear. The relationship is determined by the equation of the normal distribution, or by the distance in standard deviations from the mean of 100, or by the areas under the normal distribution curve. For example, if all of the board members score 132 on their IQ test, then the board is in the top 2% of the population of western countries. (132 is the entry level for Mensa on the Stanford-Binet scale for IQ)

7.10 The Proposed Index

For any level in the company hierarchy, for an individual or as an average for the level:

Index = IQ + Experience + SAQA Qualification Number + Health Factor

This additive model is similar to the one used in Multiple Linear Regression, where a dependent variable, in our case, the Index, depends on various factors, added together. So, our use of a similar model has solid precedents.

An alternative way of expressing the index would be to multiply the four factors together:

Index = IQ x Experience x SAQA Qualification Number x Health Factor

This multiplicative index is similar to the one used in Japanese production and maintenance systems. For example, the expression Overall Equipment Effectiveness or OEE combines Availability, Performance and Quality. This was first proposed by Seiichi Nakajima in the 1960's.

This is expressed as follows

- A = Availability = (Production Run Time)/Planned Production Time
- P = Performance = (Ideal Cycle Time x Total Count)/Run Time
- Q = Quality = (Acceptable No of Parts Produced)/Total Number of Parts Produced

So OEE = A x P x Q

The figures A, P and Q are usually expressed as numbers less than unity eg:

0.95 x 0.91 x 0.89 = 0.769 or 76.9%

If these same three factors were added together, then averaged, the result would be

(95 + 91 + 89)/3 = 91.66

So, we see that the multiplicative method results in a lower overall index than the additive method. When one of the factors is very low compared to the others, the effect is even more marked:

0.5 x 0.91 x 0.83 = 0.378 or 37.8%

(0.5 + 0.91 + 0.83)/3 = 0.766 or 76.6%

We must decide for our case what system better represents the reality. For example, if we have intelligent, experienced, well qualified persons, but they are all rather sick, how will the organisation perform? For example: (I + E + Q + H)/4 vs I x E x Q x H:

(8 + 8 + 8 + 4)/4 = 7 vs 7/9 = 77%

8 x 8 x 8 x 4 = 0.20 or 20%

Therefore, we see examples of both the additive and the multiplicative methods in industry. The advantages and disadvantages of these two approaches, additive and multiplicative, are discussed below. In Additive Models, the factors are independent of each other. For example, qualifications do not depend on experience or on health or on IQ. For experience and health this is probably true, but there will at least in some instances be a positive correlation between qualifications and IQ. Certain qualifications will only be obtainable by persons with a threshold IQ level.

As a first approximation, the four factors in the index should have equal weight. In saying this, we are assuming that the factors are of equal importance. They should then also, all cover the same range, for example, 1 to 9. This means we have to modify the factors to fit into this range, as near as is practicable. This is shown in the table below.

Factor	**Range**	**Adjusted Range**	**Approximate Adjusted Range**	**Notes**
IQ	70 - 130	Divide IQ by 14	5 - 9	
Experience in Years	2 - 40	5.6*Log (Experience)	2 – 9	Top of range rarely achieved
SAQA	1 - 9	No Adjustment	1 - 9	
Health Index	1 - 9	Divided into 5 groups of 3,6,9 each	3 - 9	

Table 7.3: Table of the Four Factors, Normalised

It is seen that only one of the factors fits into the ideal 1 – 9 range, but by the adjustments we have made, we have been able to achieve 9 for the top of the range in each case. The bottom of the range varies however from 1 to 2 to 3 to 5. There is little that can be done about this.

For example, a typical Index for Board Level = [120/14 + 5.6*log (25) + 8 + 9]/4

= [9 + 8 + 8 + 9]/4

= 34/4

= 8.5

Whereas a typical Index for the Workforce = [90/14 + 5.6*log (10) + 5 + 6]/4

= [6.4 + 5.6 + 5 + 6]/4

= 23/4

= 5.75

The ratio of these two numbers is 34/23 = approximately 1.5

With the alternative method of multiplying the four factors together we get:

Typical Index for Board Level = 5184

Typical Index for Workforce = 1075

Ratio = 4.82

Both of the above ratios express, however imperfectly, a sense of value to the organisation. For the additive index, the value of the board members seems to be about 1.5 times the value of the workforce. For the multiplicative index, the value or the board seems to be almost five times the value of the workforce. Present day salary variations would indicate the higher ratio is closer to reality, while a trade union approach would perhaps prefer the lower ratio. That is that the board members are only slightly more valuable than the workforce.

It is suggested that the additive method be used. This is the case in the practical example in Chapter 10. The index for any company will be a value between 3 and 9. The lower number would indicate a very poor amount of human capital, while a 9 would indicate excellence.

On the other hand, a multiplicative model has a much wider scale and one that is not so easily comprehensible. Its scale would run from $3^4 = 81$ to $9^4 = 6561$. Even dividing by 4 would yield the two values 20.25 and 1640.25. 1640.25 is 81 times better than 20.25, an unrealistic result, versus 3 and 9 where 9 is three times better than 9.

7.11 Chapter 7: Conclusion

Having hopefully convinced the reader that the value of a firm's human capital can be best expressed using the four parameters IQ, Health, Experience and Qualifications, this chapter describes the process of developing these four into a composite index. Discussed are questions like whether the four parameters should have equal weight, what the limiting values of the index should be and questions of linearity of the scales

Experience is one of the parameters where the number of years of experience does not add the same degree of value year upon year. Here the work of Henderson on Learning Curves is discussed and a log scale is chosen for experience.

Ordinality vs Cardinality is another factor which is considered as is whether the combined index should be additive or multiplicative. An additive model has been chosen, for the reasons given above.

Chapter 8: The Cost of a Company's Human Capital

8.1 Chapter 8: Overview

This short chapter describes the calculation for the other side of the Human Capital evaluation viz what the company has invested, in monetary terms, in human capital. The methodology is so simple as to appear simplistic, but the writer believes it to be correct, practical and of value.

8.2 The Cost of a Company's Human Capital: What you paid for it

The preceding discussion about the four measurable forms of human capital, viz employee health, experience, education and IQ are basically what the company got for its money. We now turn our attention to what the company paid for its human capital. This will be described as the commitment the company has made to its personnel.

- Firstly, a simple calculation must be done of the present value of each employee's cost to company, discounted at the firm's cost of capital, until the employee's retirement.
- Secondly, the individual calculations are added together to arrive at the value of the firm's investment in human capital

It could be argued that not everyone in the firm is going to stay on until retirement. But at the *present time,* which is what a present value calculation is all about, this is the commitment that the firm has made to the person in the position in question. But what if the person leaves? As long as the position remains on the company's organogram, then it should be filled by another person, with a similar commitment by the company to that person, with similar conditions. And hence computing what is in effect the present value of the position is the way to determine the value of the human capital for the position.

8.3 Uses of the Monetary Value of the Firm's Human Capital

The first use is to compare the Human Capital Figure with the Traditional Capital Figure. For example, for a steel mill, the human capital might be a few percent of the traditional capital. If one is able to benchmark and compare the figures for various mills, on might see various effects. For example, one mill might be seen to perform better with a lower percentage of human capital. Other things being equal (particularly the market) this might indicate overmanning in the case of the one mill. Used in conjunction with more conventional measures, such as manning levels vs tonnage output, the management might develop new insights into their operation. More human capital might actually be necessary to increase performance of the installation.

In the case of a software development company, the human capital might be by far the greater percentage of the total capital employed. In this case benchmarking against other companies might provide vital insights into corporate strategy. For example, before a merger of companies, the human capital of both should be evaluated and compared with the value the stock market puts on both companies. This would provide an extra check on the viability of the merger in the first place and effect a greater due diligence on the part of the merger team. This is more important still if the companies are not listed and hence the traditional way of assessing value from the stockmarket's point of view, is not available.

8.4 Chapter 8: Conclusion

Having determined a balance sheet value for human capital, we now have to discuss what factors are required to make the human capital work, viz management and leadership. These are discussed in the next chapter.

Chapter 9: The Management of Human Capital

9.1 Chapter 9: Overview

Having in previous chapters explained how to measure and cost an organisation's human capital, we now have to explain that having done that, ***the Effect of Management on the Organisation's Human Capital*** must still be considered. For our purposes we may describe management as the function that provides the entire infrastructure that allows the human capital to perform. If the management is adequate, the human capital will perform adequately. If the management is inadequate, then the human capital will perform inadequately. On the other hand, superior management, which provides ***leadership,*** as emphasised by J Edwards Deming, will lead to superior performance by the human capital.

Next is the need, even with a superior workforce, assessed using the four factors of Health, Experience, Qualifications and IQ, to identify the most productive persons in the workforce. Here Pareto's rule and a newer, more precise measure viz Price's Law demonstrates how this effect works, in many cases with as little as 20 percent of the workforce doing 80 percent of the work. Naturally, one of the functions of management must be an attempt to retain this 20 percent.

9.2 Managing Human Capital

Up to now we have discussed two axes of our three-axis model:

- What you paid for your human capital
- What you got for it

We can now insert a parameter into the relationship viz the Management of Human Capital. Human capital, however cheap or however expensive, however valuable or however mediocre, has to be managed if there is to be any result.

The question arises: What influence does management have on the performance of the Human Capital in the organisation? A notional graph of the effect is shown in Fig 9.1 below

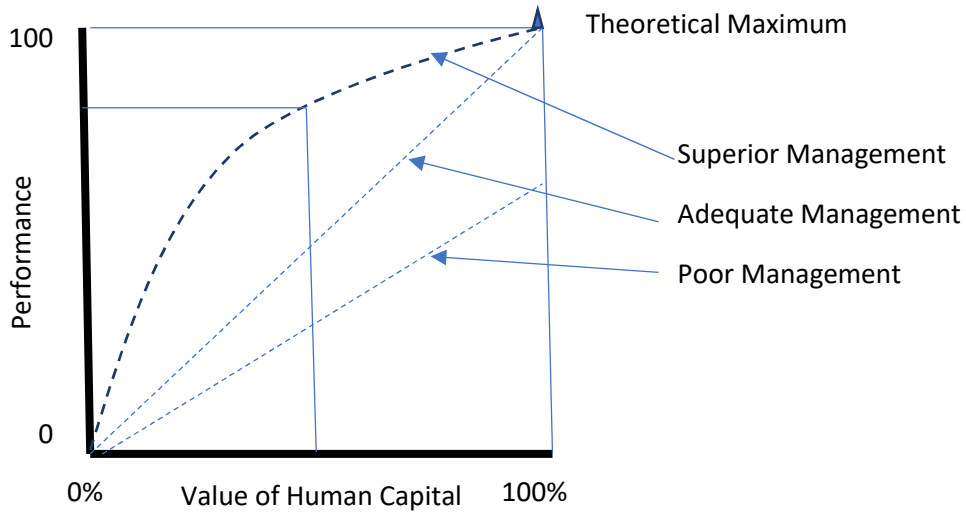

Fig. 9.1: The Effect of Management on the Organisation's Human Capital

Fig. 9.1 shows the effects of three types of management, Superior Management, Adequate Management and Poor Management.

- Superior Management has all the required systems in place but also supplies leadership and motivation. This allows the Human Capital, that is, the workforce, to perform above what we may call its established norm, resulting in exceptional performance.
- Adequate Management allows the workforce, to do what is required, without unnecessary interference and without leadership input
- Poor Management frustrates the workforce, interferes with the work and does not have all the correct systems in place. This results in sub-standard performance.

The effect of the Superior Management system is that the Human Capital can perform over and above its potential. As shown in the figure, a Human Capital value of about 50% is performing at about 80%. (This is purely notional – no actual percentage figures are implied)

The effect of Adequate Management is that the Human Capital is allowed to achieve its potential.

The effect of Poor Management is that the workforce can never achieve its potential.

9.3 Price's Law

Price's Law, (https://en.wikipedia.org/wiki/Derek_J._de_Solla_Price) was originally a postulate concerning the empirical fact that in any field of endeavour, a small percentage of

persons in that field contribute most of the research. This was demonstrated by the numbers of research papers produced.

This concept has been taken further by Prof Jordan Peterson, who has produced several You Tube videos on the subject.

Price's Law states empirically that half the work is done by the square root of the number of employees. For example, if we have 100 employees, 10 of them do half the work. This is similar to the Pareto Principle that about 20 percent of the people do about 80 percent of the work. This is demonstrated in Fig. 9.2 below:

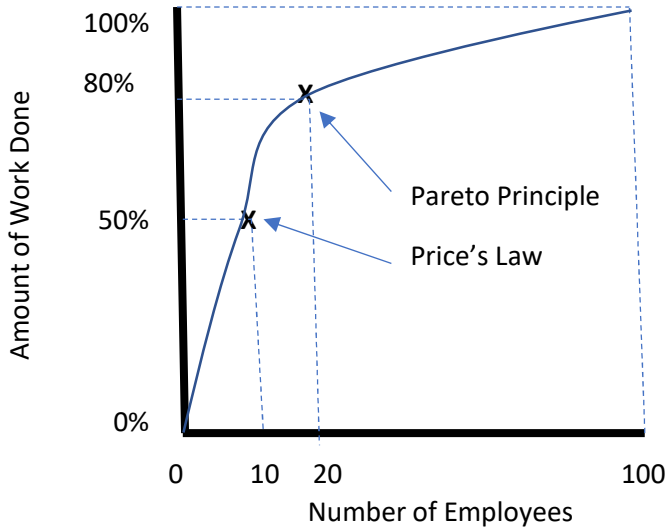

Fig. 9.2: Correlation between Price's Law and the Pareto Principle

The validity of Price's law as a general business paradigm is apparent to anyone who has worked in large or medium-sized organisations. The writer's experience was in the management, as a factory engineer, of a large staff of maintenance artisans. He had under his control about 50 persons, fitters, welders, boilermakers, electricians and building staff, along with the assistants. Two of the fitters were exceptional – all breakdown work was done by them as they had the initiative to solve problems by themselves without bothering the engineer or foreman in the middle of the night.

The electrical foreman was also exceptional, not only managing his crew but also solving problems by himself. The rest of the persons varied from adequate to mediocre.

The writer described the phenomenon in terms of the Normal Distribution, the phenomenal employees being in the right-hand tail, the majority of the artisans in the middle and a few drones in the left-hand tail.

That the Normal Distribution is an established fact goes without saying. It is well-established in industry, being used in performance evaluation reviews, statistical process control and many other applications. Be it intelligence, musical talent, sporting ability or the aptitude for certain types of work, the Normal Distribution fits any of these populations.

It is seen then that Price's Rule is the principle of the Normal Distribution expressed in other terms. One could almost say the one is a mathematical transform of the other. Or at least that Price's Rule describes the effects of being in the right-hand tail of the normal distribution – where the most productive, cleverest, most skilled, most motivated people are.

The functions of Top Management are, among others, the following

- To put in place and maintain the environment, including all the necessary systems to allow the workforce to do its work. This is analogous to Herzberg's Hygiene Scale
- To create a motivational environment ala Herzberg's Motivational Scale
- To provide Leadership as constantly emphasised by Edwards Deming
- To use Price's Law and identify those employees in the square root of the number of employees who do half the work. (This similar to Pareto's rule – that, for example, 20% of the people do 80% of the work)
- To make sure you keep these high-performing employees

What measures can we define for the management of human capital, and of those, which can be quantitatively measured?

The measure of the most importance is Productivity, defined as output over input, usually measured in financial terms. Here Price's Law comes into play. We must find who are our most productive employees.

As we have seen before, Productivity is related to Passion. It is quite easy to hire persons who are passionate about racing motorcycles, as our case in Appendix 2 of the Morbidelli company shows, but what about being passionate about bookkeeping for example? Even here, passion should play a part. The writer's Finance Professor during his MBA studies, once confessed that "the heart of a bookkeeper" pumped in his body. Therefore, even bookkeeping must work for some people.

9.4 Chapter 9: Conclusion

This chapter has demonstrated how even a superior workforce must be well managed, and how performance can be measured using the usual method of Productivity, defined as Output over Input, usually expressed in financial terms

Chapter 10: Validation of the Human Capital Evaluation Method

An Example from Industry.

10.1 Chapter 10: Overview

A validation of the Human Capital Evaluation Method was undertaken at a Water Supply company in South Africa. The maintenance department was evaluated. The Maintenance Investment was found to be 6.7% of the total asset base. The average values of the four indices were found to be

- IQ: 93
- Experience: 12 years
- SAQA years: 6
- Health: 9 (Assumed Value)

10.2 Company Description:

A Water Supply Company in South Africa, responsible for the operation and maintenance of water supply to domestic and industrial users in its municipality.

10.3 Human Resources to carry out Effective Maintenance

Our first question is what is the company's investment in maintenance personnel and how does this compare with the overall investment as described on the balance sheet? We find that the investment in maintenance personnel is 9.75% of Property, Plant and Equipment (PPE) and 6.7% of total assets. This can be compared with the cost functions in the table below.

Maintenance Cost	3.03 % of PPE
Maintenance Cost	4.35 % of Total Assets
Maintenance Investment (Entire Organisation)	9.75 % of PPE
Maintenance Investment (Entire Organisation)	6.7% of Total Assets

Table 10.1: Maintenance Ratios

The table shows that almost 10% of the PPE is human assets. The fact that the cost figures are lower than the investment figures might indicate that the investment is under-performing. Alternatively, it might indicate an over-investment in the human asset.
The investment figures above indicate what the company has paid for its investment in maintenance staff. The next question to ask is what have they bought – what is the value of the investment in operating terms. This question is divided into four parts, or indices:

- IQ
- Experience
- Qualifications
- Health

The reasons for the use of these four quantities is described in the relevant chapters above. In this particular case a fifth index was constructed, which might be described as mechanical ability.

A sample of eight persons at artisan level were tested and the results are shown in Table 7.2 below. The four indices were then normalised to roughly fit into a 1 to 9 scale. They could then be added together and divided by four to arrive at a meaningful index ranking from 1 to 10 on a cardinal scale, expressing a meaningful relative quality. For example, a value of 4 represents a quantity that is twice as good as a value of 2. The index in other words is cardinal, not ordinal. A cardinal number is one denoting quantity (one, two, three, etc.), as opposed to an ordinal number (first, second, third, etc.). If number are ordinal, one cannot say that a value of 4 is twice as great as a value of 2. On can only state that it is greater, but not by how much.

The average values of the four indices are:

- IQ: 93
- Experience: 12
- SAQA years: 6
- Health: 9 (Note this value has been assumed as it was not possible to obtain health values as there is currently no medical facility at the company. This point is discussed in detail elsewhere)

Using the table given in **Chapter 7** above, we can construct the following from the specific data for this company:

Factor	Range	Adjusted Range	Approximate Adjusted Range	Notes
IQ	70 - 130	Divide IQ by 14	5 - 9	
Experience in Years	2 - 40	5.6*Log (Experience)	2 – 9	Top of range rarely achieved
SAQA	1 - 9	No Adjustment	1 - 9	
Health Index	1 - 9	Divided into 5 groups of 3,6,9 each	3 - 9	

Table 10.2: Table of the Four Factors, Normalised

We now insert the specific values as shown in the Table below:

Factor	Value	Adjusted Range	Value of Asset	Cost of Asset
IQ	93	Divide IQ by 14	6.6	
Experience in Years	12	5.6*Log (Experience)	6.0	
Qualifications (SAQA Index)	6	No Adjustment	6	
Health Index	9	Divided into 5 groups of 3,6,9 each	9	
Arithmetic Average			6.9	R 93m

Table 10.3: Values for the Four Factors for this Case

10.4 Result:

The combined value is 6.9 on a roughly 3 to 9 scale. This figure can now be compared with the figures for other companies in the same industry, both locally and internationally. It can also be compared with the cost of the asset, viz R 93 Million. These indices are now discussed in more detail:

10.4.1 IQ

The test used the Ravens Progressive Matrices, which are culturally neutral and not language or mathematically dependent. The Sample Average was 93, which is reasonable for maintenance work. Each delegate took about 30 minutes to complete the test. The participants were enthusiastic and interested in the test results. The highest score was 106, achieved by the Maintenance Trainee, Staff No 755. It is recommended that this person should be suitable for further responsibility after additional experience and training.

An additional test, on Mechanical Comprehension was taken by some of the delegates. In this type of test, delegates are asked questions such as if a certain gear in a gear train rotates clockwise, in what direction does some other gear rotate? Here the results were not as good, as in the pure IQ test, with an average score of only 47. Once again, the Mechanical Trainee scored highest, but only with a score of 54. As regards possible future recruitment, perhaps such a test should be included as this form of intelligence has a direct bearing on a mechanic's or mechanical technician's job performance.

10.4.2 Experience: 12

This is not expressed in number of years but rather as 10*log (no. of years). This is done to reduce the scale which in the case of the company, ranges from 1 to 40, if measured in years of experience. As we are trying to give the four indices approximately equal weight, the conversion to a log scale means that the index ranges from 3 to 16.

10.4.3 SAQA Years: 6

This index is used directly as a measure of Qualifications

10.4.4 Health: 9 (Estimate)

The Health Index is non-continuous and can have values of 3, 6 or 9 for each individual. This is based on the Vitality Health rating as determined at any Vitality Health clinic in the country. When Mhlathuze Water re-opens its employee health plan, it may differ from this. If the Vitality scheme is adopted, then five factors are measured:

- Blood Glucose
- Blood Pressure
- Cholesterol
- Body Mass Index
- Smoker's Declaration

There are three ranges: In-range (value 9), Intermediate risk (value 6) and High risk (value 3) for each of the above factors. Numbers between 3, 6, and 9 are possible. For example, if one

scores 9 on four of the values and 3 on one of them, then the index for that individual will be 7.8 (calculation in Appendix 2)

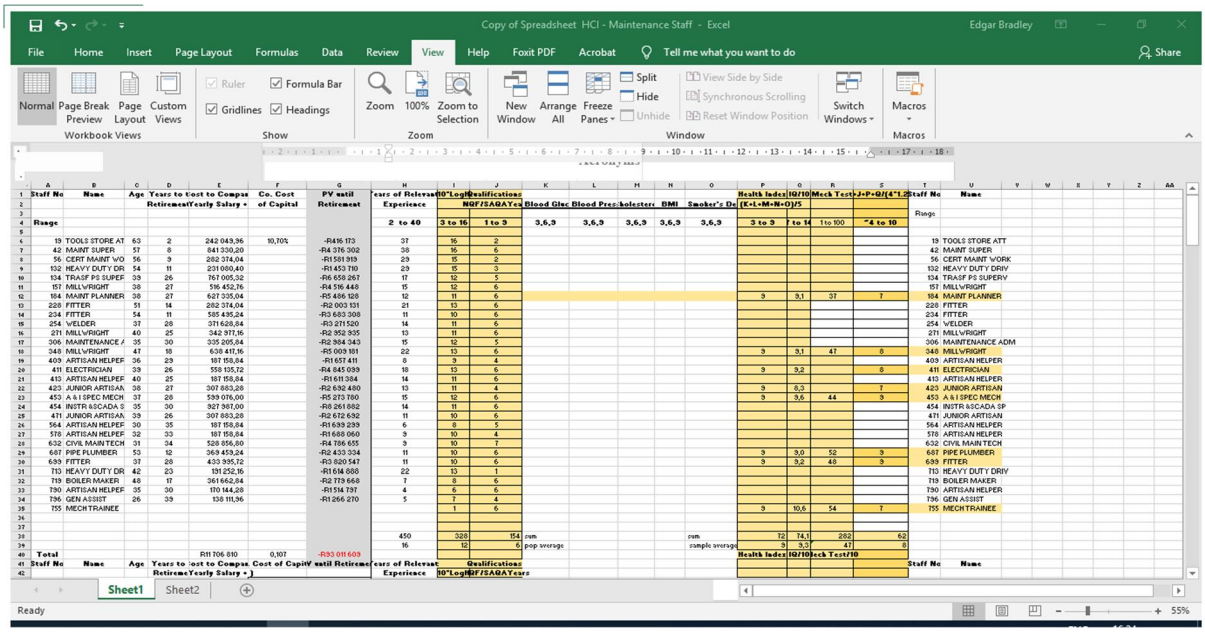

Table 10.4: Human Capital Index Calculation for Maintenance Staff at the Water Company

10.4.5 Margin of Error

The sample chosen, eight persons out of a departmental total of 31, is large enough that the results are broadly representative of the department as a whole. This is demonstrated in Table 10.5, with sample calculations given in Appendix 6.

Index	Adjusted Range	Range at 95% Confidence	Percentage Range
Years of Experience	6.0	-	-
SAQA Qualification Index	6	-	-
Health Index	9	-	-
IQ Index	6.6	7.1 - 6.0	8%
Overall Index	6.9	7.0 – 6.76	2%

Table 10.5: Values in Table 10.4 for the Eight Maintenance Staff in the Sample

10.5 Chapter 10: Conclusion

Using the method developed in Chapter 7 above, an overall index was created. This index in this case is 6.9 on a roughly 3 to 9 scale. This figure can now be compared with other

companies in the same industry, both locally and internationally. The sample chosen, eight persons out of a departmental total of 31, is large enough that the results are broadly representative of the department as a whole.

Limits of confidence apply to the IQ Index as it was computed from only eight persons out of the population of 31. When the Student -t distribution is applied to the average IQ index the result is 6.6 +/- 0.404, or about 6% at 95% confidence.

The other components of the Index use the whole population of 31 and hence no tolerance is applied to them. When applied to the overall index of 6.9, the confidence limits that apply are on quarter of those that apply to the IQ Index. (Demonstrated in Appendix 6)

So, in summary, using figures from Tables 10.1 and 10.5, the maintenance investment in the organisation is 6.7% of total assets, for which the organisation has a maintenance index of 6.9 on a possible scale of 3 to 9. How significant is this? Only further research into other organisations will answer this question.

Chapter 11: Conclusions and Further Work

11.1 Chapter 11: Overview

In conclusion a simple, quantitative method of Human Capital has been developed and demonstrated with a real-life example in a South African company.

This chapter covers possible future work in the area of the thesis viz quantitative assessments of Human Capital as well as those areas outside the scope of the present study viz Management of the Human Capital and Leadership, as well as Passion for the work, which leads to exceptional performance with under-resourced capital. One example of this is given in Appendix 2, being a case study of the Italian Morbidelli company and its phenomenal success against huge odds in Grand Prix motorcycle racing.

11.2 Factors within the Scope of this Study

In conclusion then we have established a simple, practical method for assessing human capital. Some of the literature proposes complex schemes where the complexity seems to add little value. The aim of the present research has been to develop a simple, practical scheme which adds real value and conforms to generally accepted accounting practice. This scheme has been established from two points of view: What the company has paid for the human asset and what the inherent value is of the asset.

The method chosen to determine the cost of the asset is to assess each employee's cost to company until retirement age, discounted at the firm's cost of capital. Some would argue, but what if the person leaves before retirement? The answer to this is that the position is to be filled and therefore the costs will continue. This technique is in line with established accounting principles; the balance sheet is a snapshot of the company at a certain point in its history. Next year, positions might have been scrapped and a new reality would present itself on the balance sheet.

This cost of human capital to the company can be used as follows: The human capital can be compared with the traditional capital. If a data base has been built up of various companies, the ratio of the two types of capital can be compared. Perhaps the company needs more human capital, perhaps less.

With regards to the other side of the equation, the value of human capital that has been purchased, this is found by the formula which combines the four items, IQ, experience, qualifications and health. The result is expressed as a number between 3 and 9, the lower number indicating a poor amount of human capital and the upper number indicating excellence.

It was possible to test the proposals of this research on a real live case, viz a water supply company in South Africa., where a statistical sample of the company's maintenance staff produced an Index of 6.9 out of a possible score of 9. The cost to the company of the entire maintenance staff was found to be R93 million. This comprises 6.7% when compared with the traditional asset base.

11.3 Factors outside of the Scope of this Study

11.3.1 Management and Leadership

Apart from the computation of the two sides of human capital it is recognised that even with the best workforce, ***management*** of the same is still necessary. This comprises two concepts:

- The first is simply the ***basic management issue***: Providing the environment that will maximise the productivity of the human asset base. This includes basic things like office space (or the ability to work from home), procedures, personnel policy, remuneration etc. In terms as used by Herzberg, these are Hygiene Issues
- The second function of the management is to provide ***motivation*** according to the classic Herbergian formulae, e.g., interesting work, challenging work, possibility of advancement and recognition. These can alternatively be called ***leadership issues***, as discussed by Deming.

11.3.3 The Third and Final Factor: Passion for the Work

Finally, it must be admitted that even with the best human capital and the best management, there might still be something else that is required for optimum performance. The current vogue word for this is ***passion,*** also described by others as ***determination*** or "***grit".*** Hence the example quoted in Appendix 2, which the writer has called the ***Morbidelli Effect,*** where pure passion for the job overcame obstacles of finance, company size, experience and reputation.

11.4 A Summary: A Complete Vision for Human Capital Management

This research only covers the quantification of Human Capital. It is recognised however that this human capital still has to be properly managed if its full value is to be realised. This management function can be divided into two parts; what we shall call simple management, meaning the "nuts and bolts" of management, for example the provision of physical facilities, an HR function, etc. Apart from this it is necessary for the management to provide Leadership,

which is described here as setting an example and providing the correct motivational atmosphere. These two facets of management correspond the two scales defined by Herzberg as the Hygiene scale and the Motivation scale. They are also supported by the writings of Deming on the subject of management,

Human Capital Cost	**Human Capital Value**	**Management**	**Leadership/ Motivation**	**Passion**
Have we overpaid?	Is it sufficient?	Work conditions OK?	A Leader sets the Example	For the Workforce and the Management – does it exist?
What is the Ratio of Human Capital to Traditional Capital?	What are the Indices?	Are all relevant Procedures in place?	Is the Work Challenging?	Passion is hard to measure - the results show the effect
What is the Benchmark for this Ratio?		Company Infrastructure complete?	Is the Work Interesting?	
		Company Policy in place?	Is real Recognition in place? (Not employee of the month, etc)	
			Possibility of Promotion in place?	
		Have we found our most productive employees according to Price's Law?		

Table 11.1: A Checklist for Human Capital Management

Apart from this management of human capital, another and final requirement, on the part of the workforce and the management, is Passion, meaning an intense interest in the job. Companies exist without this, but outstanding performance requires it. The Morbidelli Case in

Appendix 2 is the most telling example of passion in the workplace that the writer has been able to find. To clarify these concepts, the table below is a checklist of the more serious questions to ask concerning the management of human capital:

11.5 Future Work

Future work could be the development of a data base of companies' human capital. For example, a civil engineering consulting consultancy with offices in Johannesburg and Cape Town, might wish to compare the human capital in the two locations. As a second example, a company in Johannesburg with two factories, one making air-conditioning equipment and the other electronic devices, might like to compare the human capital at the two locations. International comparisons would be the next step and it is hoped that an international human capital consultancy could be developed, perhaps in conjunction with the university.

11.6 Chapter 11: Conclusion

The chapter ends with a checklist of the more serious questions to ask concerning the management of human capital, both quantitative and qualitative, under the five headings:

- What did the Human Capital cost the company?
- What is the value of the Human Capital?
- Management issues
- Leadership issues
- Passion

Finally, it is suggested that a database be developed of companies willing to have their human capital assessed by the methods outlined in this treatise. This is beyond the scope of the writer, but it is suggested that a university could establish a centre for such a data base.

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Appendix 1: Psychological Testing Methods

This Appendix describes the terms used in the Schmidt and Hunter analysis, assembled here for easy reference. They are also included in Schmidt and Hunter's paper in Appendix 4.

Assessment Centre: Assessment Centres are used to evaluate managerial candidate, using:

- Different types of psychological tests
- Management games
- In-basket exercises. Here, the candidate is asked to solve different management problems.
- Group discussion (GD) about different management topics.
- Oral presentations of management topics.
- Report writing, etc

Behavioural Consistency Method: The performance of a given applicant in response to certain questions can be considered to consist of the achievements he or she recalls and chooses to write down in response.

Big Five Personality traits: As developed by Costa and McCrae: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

Biographical Data Measures (Biodata): Biodata measures are based on the measurement principle of behavioural consistency, that is, past behaviour is the best predictor of future behaviour. For example, biodata test items are developed through behavioural examples provided by subject matter experts (SMEs). These items specify situations likely to have occurred in a person's life, and ask about the person's typical behaviour in the situation. An item might ask "How many books have you read in the last 6 months?" or "How often have you put aside tasks to complete another, more difficult assignment?" Test takers choose one of several predetermined alternatives to best match their past behaviour and experiences. Self-administered

Cognitive Assessment: Also known as intelligence testing. Used to determine an individual's general thinking and reasoning abilities, also known as intellectual functioning or IQ

Conscientiousness Test: Conscientiousness is one of the five personality traits of the Big Five personality theory. A person scoring high in conscientiousness usually has a high level of self-discipline. These individuals prefer to follow a plan, rather than act spontaneously. Their methodical planning and perseverance usually make them highly successful in their chosen occupation. Self-administered

Employment Interview: Structured: A structured job interview is a standardized way of comparing job candidates. The employer creates interview questions focused on the skills and abilities the company is seeking. Each interviewee is asked the exact same questions, in the exact same order

GMA Tests: These are tests of general mental ability which include scales that measure specific constructs such as verbal, mechanical, numerical, social, and spatial ability. The social test battery can be politically biased

Graphology is the analysis of the physical characteristics and patterns of handwriting claiming to be able to identify the writer, indicating the psychological state at the time of writing, or evaluating personality characteristics. It is generally considered a pseudoscience, or even to be part of the occult

Integrity Tests: Self-administered tests to check a candidate's honesty. Suffers the same problems as all self-administered tests

Job knowledge tests, sometimes referred to as achievement or mastery tests, typically consist of questions designed to assess technical or professional expertise in specific knowledge areas. Job knowledge tests evaluate what a person knows at the time of taking the test.

Job Tryout Procedure: This is an online, interactive, pre-employment test that is composed of eight sections: job preview, similar job-related tasks, test-drive job tasks, on-the-job problem solving, work history questionnaire, simulation scenarios, and work-style questionnaire

Meta-analysis: A meta-analysis is a statistical analysis that combines the results of multiple scientific studies. Meta-analysis can be performed when there are multiple scientific studies addressing the same question, with each individual study reporting measurements that are expected to have some degree of error.

Peer Ratings: Often used to check a candidate's responses to a Big Five Test. Usually only applicable to internal candidates

Reference Checks: Reference checking is primarily used to verify the accuracy of information given by job applicants through other selection processes (e.g., résumés, occupational questionnaires and interviews) Also claimed to predict the success of job applicants by comparing their experience to the competencies required by the job.

T & E: Training and Experience

Work Sample Tests are based on the premise that the best predictor of future behaviour is observed behaviour under similar situations. These tests require the examinee to perform tasks that are similar to those that are performed on the job.

Appendix 2: The Morbidelli Effect

This Appendix is included to illustrate that despite the numerate efficiency of the author's proposed index, other, unmeasurable factors are also important for a company to achieve excellent performance. This most important unmeasurable factor is: ***Passion***

A Case Study: Passion: The Morbidelli Effect: A true case of a David against several Goliaths

Management brings together people with the correct indices but with an added ingredient: passion.

Giancarlo Morbidelli is an Italian entrepreneur from Pesaro in Italy. His firm began as a woodworking shop, building furniture and wooden coach bodies for cars. Later he was to make woodworking machinery. His business grew to have 300 employees.

This case study is not about this phase of his life, but about his subsequent venture into the manufacture of racing motorcycles, a venture he admits to financing from his woodworking machinery company's profits. As a proven exercise in productivity, his record is amazing. The Morbidelli team won the 125 cc world championship in 1975, 1976 and 1977, and won the 250 cc championship in 1977.

Motorcycle competition in that era was dominated by Japanese companies that had huge resources and large budgets. Honda, followed by Yamaha, Kawasaki and Suzuki had been winning world championships since 1961. Italian and other European teams had left the field except for MV Agusta, who continued in the larger capacity classes until 1973. There was an odd win by a European team in the smaller classes (Benelli, 250 cc, in 1969 and Derbi, 125cc in 1971 and 1972).

The German, Jorg Moeller, was one of the engineers hired by Morbidelli to develop their racing bikes. Speaking of their racing "factory", he said: "It was a small room, four or five metres by ten metres long. When the Japanese saw it, they looked into each other's eyes and got scared! One of Suzuki's men said: "We employ between 200 and 300 engineers – how can you do it by yourself?"

Giancarlo takes up the story: "The Suzuki Team Manager asked my how many bikes I produced every year and where I sold them. He wanted to know what my business was about.

I said I made two bikes this year and one in the past year. He said what? Yes, I said I sell woodworking machinery. This is only my hobby."

When asked how all this was achieved – designing and making the bikes, racing them and winning, with a team of a few engineers, mechanics and riders (perhaps ten people in total), Giancarlo said that the main requirement for every member of the team was ***passion*** – passion for motorcycles and passion for racing them.

Secondly, "What was special here was the tight relationship and the friendship among the people. The mechanics here were not specialised – the person who set the frame was also in charge of taking the engine apart. It wasn't super-professional, but it worked."

Up until 1976 Morbidellis were not available for sale to private racers - only the team's own works riders could race on them. Many private riders asked for a bike to race in the World Championship. Morbidelli obliged by teaming up with the Benelli Armi motorcycle company A new factory was built with help from Benelli Armi in Pesaro, called the MBA factory (Morbidelli-Benelli-Armi), to produce Morbidelli motorcycles of 125 cc and 250 cc in quantity. These were raced successfully for several more years.

Moeller again: "They used one of Benelli's buildings and started production. It was very similar to the factory bike. One of the first four motorcycles went to Japan. The chief of the Kawasaki racing team bought it from our Dutch dealer. He didn't even want the frame – he just cared about the engine. A complete engine with the exhaust and everything else. He was spying on us, everybody wanted to know how the engine was made. We were ten seconds per lap faster than the Yamaha in Brno. The same in Hockenheim. We lapped the first factory Yamaha on the 8km circuit."

The MBA team won the 125 cc World Championship in year 1978 and in 1980. Morbidelli continued in Grand Prix competition until the 1982 season. The winning stopped when the Morbidelli family lost interest – Giancarlo's son began car racing in Formula 1, with the father supplying the necessary finance and encouragement.

All that now remains of the Morbidelli enterprise is the Morbidelli Motorcycle Museum in Pesaro, housing the full family of Morbidelli racing bikes and many other makes as well.

Appendix 3: Qualifications: SAQA and the NQF

The NQF is a framework, ie it sets the boundaries, principle and guidelines, which provide a vision, a philosophical base and an organisational structure, for the construction of a qualifications system. Detailed development and implementation is carried out within these boundaries. All education and training in South Africa fits within this framework.

It is national because it is a national resource, representing a national effort at integrating education and training into unified structure of recognised qualifications. It is framework of qualifications i.e., records of learner achievements. The NQF is a set of principles and guidelines by which records of learner achievement are registered to enable national recognition of acquired skills and knowledge, thereby ensuring an integrated system that encourages lifelong learning. The NQF consist of 10 levels divided into three bands:

- Levels 1 to 4 equate to high school grades 9 to 12 or vocational training
- 5 to 7 are college diplomas and technical qualifications
- 7 to 10 are university degrees.

Level	Designation
1	High School Grade 9
2	Grade 10 (High School) and National Certificate Level 2 (Vocational)
3	Grade 11 (High School) and National Certificate Level 3 (Vocational)
4	Grade 12 (National Senior Certificate) and National Certificate Level 4 (Voc)
5	Higher Certificates and Advanced National Certificate (Vocational)
6	National Diploma and Advanced Certificates
7	Batchelor's Degree, Advanced Diplomas, Post Graduate Certificate and B-tech
8	Honours Degree, Post Graduate Diploma and Professional Qualifications
9	Master's Degree
10	Doctorate

Table A3:1 Qualifications: SAQA and the NQF

Appendix 4: Excepts from a Paper by Schmidt and Hunter

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The Validity and Utility of Selection Methods in Personnel Psychology: Practical and Theoretical Implications of 85 Years of Research Findings

Frank L. Schmidt
University of Iowa
John E. Hunter
Michigan State University

This article summarizes the practical and theoretical implications of 85 years of research in personnel selection. On the basis of meta-analytic findings, this article presents the validity of 19 selection procedures for predicting job performance and training performance and the validity of paired combinations of general mental ability (GMA) and the 18 other selection procedures. Overall, the 3 combinations with the highest multivariate validity and utility for job performance were GMA plus a work sample test (mean validity of .63), GMA plus an integrity test (mean validity of .65), and GMA plus a structured interview (mean validity of .63).

A further advantage of the latter 2 combinations is that they can be used for both entry level selection and selection of experienced employees. The practical utility implications of these summary findings are substantial. The implications of these research findings for the development of theories of job performance are discussed. From the point of view of practical value, the most important property of a personnel assessment method is predictive validity: the ability to predict future job performance, job-related learning (such as amount of learning in training and development programs), and other criteria. The predictive validity coefficient is directly proportional to the practical economic value (utility) of the assessment method (Brogden, 1949; Schmidt, Hunter, McKenzie, & Muldrow, 1979).

Use of hiring methods with increased predictive validity leads to substantial increases in employee performance as measured in percentage increases in output, increased monetary value of output, and increased learning of job-related skills (Hunter, Schmidt, & Judiesch, 1990). Today, the validity of different personnel measures can be determined with the aid of

85 years of research. The most well-known conclusion from this research is that for hiring employees without previous experience in the job the most valid predictor of future performance and learning is general mental ability ([GMA], i.e., intelligence or general cognitive ability; Hunter & Hunter, 1984; Ree & Earles, 1992). GMA can be measured using commercially available tests. However, many other measures can also contribute to the overall validity of the selection process. These include, for example, measures of Frank L. Schmidt, Department of Management and Organization, University of Iowa; John E. Hunter, Department of Psychology, Michigan State University.

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On the basis of meta-analytic findings, this article examines and summarizes what 85 years of research in personnel psychology has revealed about the validity of measures of 19 different selection methods that can be used in making decisions about hiring, training, and developmental assignments. In this sense, this article is an expansion and updating of Hunter and Hunter (1984). In addition, this article examines how well certain combinations of these methods work. These 19 procedures do not all work equally well; the research evidence indicates that some work very well and some work very poorly. Measures of GMA work very well, for example, and graphology does not work at all. The cumulative findings show that the research knowledge now available makes it possible for employers today to substantially increase the productivity, output, and learning ability of their workforces by using procedures that work well and by avoiding those that do not. Finally, we look at the implications of these research findings for the development of theories of job performance.

Determinants of Practical Value (Utility) of Selection Methods

The validity of a hiring method is a direct determinant of its practical value, but not the only determinant. Another direct determinant is the variability of job performance. At one extreme, if variability were zero, then all applicants would have exactly the same level of later job

performance if hired. In this case, the practical value or utility of all selection procedures would be zero. In such a hypothetical case, it does not matter who is hired, because all workers are the same. At the other extreme, if performance variability is very large, it then becomes important to hire the best performing applicants and the practical utility of valid selection methods is very large. As it happens, this "extreme" case appears to be the reality for most jobs.

Research over the last 15 years has shown that the variability of performance and output among (incumbent) workers is very large and that it would be even larger if all job applicants were hired or if job applicants were selected randomly from among those that apply (cf. Hunter et al., 1990; Schmidt & Hunter, 1983; Schmidt et al., 1979). This latter variability is called the applicant pool variability, and in hiring this is the variability that operates to determine practical value. This is because one is selecting new employees from the applicant pool, not from among those already on the job in question.

The variability of employee job performance can be measured in a number of ways, but two scales have typically been used: dollar value of output and output as a percentage of mean output. The standard deviation across individuals of the dollar value of output (called *SDy)* has been found to be at minimum 40% of the mean salary of the job (Schmidt & Hunter, 1983; Schmidt et al., 1979; Schmidt, Mack, & Hunter, 1984). The 40% figure is a lower bound value; actual values are typically considerably higher. Thus, if the average salary for a job is $40,000, then SD*,* is at least $16,000. If performance has a normal distribution, then workers at the 84th percentile produce $16,000 more per year than average workers (i.e., those at the 50th percentile).

And the difference between workers at the 16th percentile (' 'below average'' workers) and those at the 84th percentile ("superior" workers) is twice that: $32,000 per year. Such differences are large enough to be important to the economic health of an organization.

Employee output can also be measured as a percentage of mean output; that is, each employee's output is divided by the output of workers at the 50th percentile and then multiplied by 100. Research shows that the standard deviation of output as a percentage of average output (called *SDf)* varies by job level. For unskilled and semi-skilled jobs, the average *SDf* figure is 19%. For skilled work, it is 32%, and for managerial and professional jobs, it is 48% (Hunter et al., 1990). These figures are averages based on all available studies that measured or counted the amount of output for different employees. If a superior worker is defined as one whose performance (output) is at the 84th percentile (that is, 1 *SD* above the mean), then a

superior worker in a lower-level job produces 19% more output than an average worker, a superior skilled worker produces 32% more output than the average skilled worker, and a superior manager or professional produces output 48% above the average for those jobs. These differences are large and they indicate that the payoff from using valid hiring methods to predict later job performance is quite large.

Another determinant of the practical value of selection methods is the selection ratio - the proportion of applicants who are hired. At one extreme, if an organization must hire all who apply for the job, no hiring procedure has any practical value. At the other extreme, if the organization has the luxury of hiring only the top scoring 1%, the practical value of gains from selection per person hired will be extremely large. But few organizations can afford to reject 99% of all job applicants. Actual selection ratios are typically in the .30 to .70 range, a range that still produces substantial practical utility.

What we have presented here is not, of course, a comprehensive discussion of selection utility. Readers who would like more detail are referred to the research articles cited above and to Boudreau (1983a, 1983b, 1984), Cascio and Silbey (1979), Cronshaw and Alexander (1985), Hunter, Schmidt, and Coggin (1988), Hunter and Schmidt (1982a, 1982b), Schmidt and Hunter (1983), Schmidt, Hunter, Outerbridge, and Tratmer (1986), Schmidt, Hunter, and Pearlman (1982), and Schmidt et al. (1984). Our purpose here is to make three important points: (a) the economic value of gains from unproved hiring methods are typically quite large, (b) these gains are directly proportional to the size of the increase in validity when moving from the old to the new selection methods, and (c) no other characteristic of a personnel measure is as important as predictive validity.

Research studies assessing the ability of personnel assessment methods to predict future job performance and future learning (e.g., in training programs) have been conducted since the first decade of the 20th century. However, as early as the 1920s it became apparent that different studies conducted on the same assessment procedure did not appear to agree in their results. Validity estimates for the same method and same job were quite different for different studies. During the 1930s and 1940s the belief developed that this state of affairs resulted from subtle differences between jobs that were difficult or impossible for job analysts and job analysis methodology to detect. That is, researchers concluded that the validity of a given procedure really was different in different settings for what appeared to be basically the same job, and that the conflicting findings in validity studies were just reflecting this fact of reality. This belief, called the theory of situational specificity, remained dominant in personnel psychology until the late 1970s when it was discovered that most of the differences across

studies were due to statistical and measurement artefacts and not to real differences in the jobs (Schmidt & Hunter, 1977; Schmidt, Hunter, Pearlman, & Shane, 1979). The largest of these artefacts was simple sampling error variation, caused by the use of small samples in the studies. (The number of employees per study was usually in the 40-70 range.) This realization led to the development of quantitative techniques collectively called meta-analysis that could combine validity estimates across studies and correct for the effects of these statistical and measurement artefacts (Hunter & Schmidt, 1990; Hunter, Schmidt, & Jackson, 1982). Studies based on meta-analysis provided more accurate estimates of the average operational validity and showed that the level of real variability of validities was usually quite small and might in fact be zero (Schmidt, 1992; Schmidt et a]., 1993).

In fact, the findings indicated that the variability of validity was not only small or zero across settings for the same type of job, but was also small across different kinds of jobs (Hunter, 1980; Schmidt, Hunter, & Pearlman, 1980). These findings made it possible to select the most valid personnel measures for any job. They also made it possible to compare the validity of different personnel measures for jobs in general, as we do in this article. Table 1 summarizes research findings for the prediction of performance on the job. The first column of numbers in Table 1 shows the estimated mean validity of 19 selection methods for predicting performance on the job, as revealed by meta-analyses conducted over the last 20 years. Performance on the job was typically measured using supervisory ratings of job performance, but production records, sales records, and other measures were also used. The sources and other information about these validity figures are given in the notes to Table 1. Many of the selection methods in Table 1 also predict job-related learning; that is, the acquisition of job knowledge with experience on the job, and the amount learned in training and development programs. However, the overall amount of research on the prediction of learning is less. For many of the procedures in Table 1, there is little research evidence on their ability to predict future job-related-leaming. Table 2 summarizes available research findings for the prediction of performance in training programs. The first column in Table 2 shows the mean validity of 10 selection methods as revealed by available meta-analyses. In the vast majority of the studies included in these meta-analyses, performance in training was assessed using objective measures of amount learned on the job; trainer ratings of amount learned were used in about 5% of the studies.

Unless otherwise noted in Tables 1 and 2, all validity estimates in Tables 1 and 2 are corrected for the downward bias due to measurement error in the measures of job performance and to range restriction on the selection method in incumbent samples relative to applicant

populations. Observed validity estimates so corrected estimate operational validities of selection methods when used to hire from applicant pools. Operational validities are also referred to as true validities.

In the pantheon of 19 personnel measures in Table 1, GMA (also called general cognitive ability and general intelligence) occupies a special place, for several reasons. First, of all procedures that can be used for all jobs, whether entry level or advanced, it has the highest validity and lowest application cost. Work sample measures are slightly more valid but are much more costly and can be used only with applicants who already know the job or have been trained for the occupation or job. Structured employment interviews are more costly and, in some forms, contain job knowledge components and therefore are not suitable for inexperienced, entry level applicants. The assessment center and job tryout are both much more expensive and have less validity. Second, the research evidence for the validity of OMA measures for predicting job performance is stronger than that for any other method (Hunter, 1986; Hunter & Schmidt, 1996; Ree & Earles, 1992; Schmidt & Hunter, 1981). Literally thousands of studies have been conducted over the last nine decades. By contrast, only 89 validity studies of the structured interview have been conducted (McDaniel, Whetzel, Schmidt, & Mauer, 1994). Third, GMA has been shown to be the best available predictor of job-related learning. It is the best predictor of acquisition of job knowledge on the job (Schmidt & Hunter, 1992; Schmidt, Hunter, & Outerbridge, 1986) and of performance in job training programs (Hunter, 1986; Hunter & Hunter, 1984; Ree & Earles, 1992). Fourth, the theoretical foundation for GMA is stronger than for any other personnel measure.

Serial Number	Measure	Validity r
1	GMA tests	0.51
2	Work sample tests	0.54
3	Integrity tests	0.41
4	Conscientiousness tests	0.31
5	Employment interviews (structured)	0.51
6	Employment interviews (unstructured)	0.38
7	Job knowledge tests	0.48
8	Job try-out procedure	0.44

9	Peer ratings	0.49
10	T & E behavioural consistency method	0.45
11	Reference checks	0.26
12	Job experience (years)	0.18
13	Biographical data measures	0.35
14	Assessment centres	0.37
15	T & E point method	0.11
16	Years of Education	0.10
17	Interests	0.10
18	Graphology	0.02
19	Age	-0.01

Table 1: ***Predictive Validity for Overall Job Performance of General Mental Ability (GMA) Scores. Combined with a Second Predictor Using (Standardized) Multiple Regression***

Because of its special status, **GMA** can be considered the primary personnel measure for hiring decisions, and one can consider the remaining 18 personnel measures as supplements to GMA measures. That is, in the case of each of the other measures, one can ask the following question: When used in a properly weighted combination with a GMA measure, how much will each of these measures increase predictive validity or job performance over the .51 that can be obtained by using only GMA? This "incremental validity" translates into incremental utility, that is, into increases in practical value. Because validity is directly proportional to utility, the percentage of increase in validity produced by the adding the second measure is also the percentage of increase in practical value (utility). The increase in validity (and utility) depends not only on the validity of the measure added to GMA, but also on the correlation between the two measures.

The correlations between mental ability measures and the other measures were estimated from the research literature (often from meta-analyses); the sources of these estimates are given in the notes to Table 1. To appropriately represent the observed score correlations between predictors in applicant populations, we corrected all correlations between GMA and

other predictors for range restriction but not for measurement error in the measure of either predictor.

Consider work sample tests. Work sample tests are hands-on simulations of part or all of the job that must be performed by applicants. For example, as part of a work sample test, an applicant might be required to repair a series of defective electric motors. Work sample tests are often used to hire skilled workers, such as welders, machinists, and carpenters. When combined in a standardized regression equation with GMA, the work sample receives a weight of .41 and GMA receives a weight of .36. The validity of this weighted sum of the two measures (the multiple *R)* is .63, which represents an increment of .12 over the validity of GMA alone. This is a 24% increase in validity over that of GMA alone—and also a 24% increase in the practical value (utility) of the selection procedure. As we saw earlier, this can be expressed as a 24% increase in the gain in dollar value of output. Alternatively, it can be expressed as a 24% increase in the percentage of increase in output produced by using GMA alone. In either case, it is a substantial improvement.

Work sample tests can be used only with applicants who already know the job. Such workers do not need to be trained, and so the ability of work sample tests to predict training performance
has not been studied.

Integrity tests are used in industry to hire employees with reduced probability of counterproductive job behaviours, such as drinking or drugs on the job, fighting on the job, stealing from the employer, sabotaging equipment, and other undesirable behaviours. They do predict these behaviours, but they also predict evaluations of overall job performance (Ones, Viswesvaran, & Schmidt, 1993). Even though their validity is lower, integrity tests produce a larger increment in validity (.14) and a larger percentage of increase in validity (and utility) than do work samples. This is because integrity tests correlate zero with GMA (vs. .38 for work samples). In terms of basic personality traits, integrity tests have been found to measure mostly conscientiousness, but also some components of agreeableness and emotional stability (Ones, 1993).

The figures for **conscientiousness measures** per se are given in Table 1. The validity of conscientiousness measures (Mount & Barrick, 1995) is lower than that for integrity tests (.31 vs. .41), its increment to validity is smaller (.09), and its percentage of increase in validity is smaller (18%). However, these values for conscientiousness are still large enough to be practically useful. A meta-analysis based on 8 studies and 2,364 individuals estimated the

mean validity of integrity tests for predicting performance in training programs at .38 (Schmidt, Ones, & Viswesvaran, 1994). In the prediction of training performance, integrity tests appear to produce higher incremental validity than any other measure studied to date. However, the increment in validity produced by measures of conscientiousness (.09, for a 16% increase) is only slightly smaller. The validity estimate for conscientiousness is based on 21 studies and 4,106 individuals (Mount & Barrick, 1995), a somewhat larger database.

Employment interviews can be either **structured or unstructured** (Huffcutt, Roth, & McDaniel, 1996; McDaniel et al., 1994). Unstructured interviews have no fixed format or set of questions to be answered. In fact, the same interviewer often asks different applicants different questions. Nor is there a fixed procedure for scoring responses; in fact, responses to individual questions are usually not scored, and only an overall evaluation (or rating) is given to each applicant, based on summary impressions and judgments**. Structured interviews** are exactly the opposite on all counts. In addition, the questions to be asked are usually determined by a careful analysis of the job in question. As a result, structured interviews are more costly to construct and use, but are also more valid. As shown in Table 1, the average validity of the structured interview is .51, versus .38 for the unstructured interview (and undoubtedly lower for carelessly conducted unstructured interviews). An equally weighted combination of the structured interview and a GMA measure yields a validity of .63. As is the case for work sample tests, the increment in validity is .12 and the percentage of increase is 24%. These figures are considerably smaller for the unstructured interview (see Table 1). Clearly, the combination of a structured interview and a GMA test is an attractive hiring procedure. It achieves 63% of the maximum possible practical value (utility), and does so at reasonable cost.

The next procedure in Table 1 is **job knowledge tests**. Like work sample measures, job knowledge tests cannot be used to evaluate and hire inexperienced workers. An applicant cannot be expected to have mastered the job knowledge required to perform a particular job unless he or she has previously performed that job or has received schooling, education, or training for that job. But applicants for jobs such as carpenter, welder, accountant, and chemist can be administered job knowledge tests. Job knowledge tests are often constructed by the hiring organization on the basis of an analysis of the tasks that make up the job. Constructing job knowledge tests in this manner is generally somewhat more time consuming and expensive than constructing typical structured interviews. However, such tests can also be purchased commercially; for example, tests are available that measure the job knowledge required of machinists (knowledge of metal cutting tools and procedures). Other examples are tests of knowledge of basic organic chemistry and tests of the knowledge required of roofers.

In an extensive meta-analysis, Dye, Reck and McDaniel (1993) found that commercially purchased job knowledge tests ("off the shelf" tests) had slightly lower validity than job knowledge tests tailored to the job in question. The validity figure of .48 in Table 1 for job knowledge tests is for tests tailored to the job in question. As shown in Table 1, job knowledge tests increase the validity by .07 over that of GMA measures alone, yielding a 14% increase in validity and utility. Thus, job knowledge tests can have substantial practical value to the organization using them. For the same reasons indicated earlier for job sample tests, job knowledge tests typically have not been used to predict performance in training programs. Hence, little validity information is available for this criterion.

The next three personnel measures in Table 1 increase validity and utility by the same amount as job knowledge tests (i.e.,14%). However, two of these methods are considerably less practical to use in many situations. Consider **the job try-out procedure**. Unlike job knowledge tests, the job try-out procedure can be used with entry level employees with no previous experience on the job in question. With this procedure, applicants are hired with minimal screening and their performance on the job is observed and evaluated for a certain period of time (typically 6-8 months). Those who do not meet a previously established standard of satisfactory performance by the end of this probationary period are then terminated. If used in this manner, this procedure can have substantial validity (and incremental validity), as shown in Table 1. However, it is very expensive to implement, and low job performance by minimally screened probationary workers can lead to serious economic losses. In addition, it has been our experience that supervisors are reluctant to terminate marginal performers. Doing so is an unpleasant experience for them, and to avoid this experience many supervisors gradually reduce the standards of minimally acceptable performance, thus destroying the effectiveness of the procedure.

Another consideration is that some of the benefits of this method will be captured in the normal course of events even if the job try-out procedure is not used, because clearly inadequate performers will be terminated after a period of time anyway.

Peer ratings are evaluations of performance or potential made by one's co-workers; they typically are averaged across peer raters to increase the reliability (and hence validity) of the ratings. Like the job try-out procedure, peer ratings have some limitations. First, they cannot be used for evaluating and hiring applicants from outside the organization; they can be used only
for internal job assignment, promotion, or training assignment. They have been used extensively for these internal personnel decisions in the military (particularly the U.S. and

Israeli militaries) and some private firms, such as insurance companies. One concern associated with peer ratings is that they will be influenced by friendship, or social popularity, or both. Another is that pairs or clusters of peers might secretly agree in advance to give each other high peer ratings. However, the research that has been done does not support these fears; for example, martialling friendship measures out of the peer ratings does not appear to affect the validity of the ratings (cf. Hollander, 1956; Waters & Waters, 1970).

The **T & E behavioural consistency method** of evaluating previous training and experience (McDaniel, Schmidt, & Hunter, 1988a; Schmidt, Caplan, et al., 1979) is based on the well-established psychological principle that the ***best predictor of future performance is past performance.*** In developing this method, the first step is to determine what achievement and accomplishment dimensions best separate top job performers from low performers. This is done on the basis of information obtained from experienced supervisors of the job in question, using a special set of procedures (Schmidt, Caplan, et al., 1979). Applicants are then asked to describe (in writing or sometimes orally) their past achievements that best illustrate their ability to perform these functions at a high level (e.g., organizing people and getting work done through people). These achievements are then scored with the aid of scales that are anchored at various points by specific scaled achievements that serve as illustrative examples or anchors.

Use of the behavioural consistency method is not limited to applicants with previous experience on the job in question. Previous experience on jobs that are similar to the current job in only very general ways typically provides adequate opportunity for demonstration of achievements. In fact, the relevant achievements can sometimes be demonstrated through community, school, and other nonjob activities. However, some young people just leaving secondary school may not have had adequate opportunity to demonstrate their capacity for the relevant achievements and accomplishments; the procedure might work less well in such groups. In terms of time and cost, the behavioural consistency procedure is nearly as time consuming and costly to construct as locally constructed job knowledge tests. Considerable work is required to construct the procedure and the scoring system; applying the scoring procedure to applicant responses is also more time consuming than scoring of most job knowledge tests and other tests with clear right and wrong answers. However, especially for higher level jobs, the behavioural consistency method may be well worth the cost and effort. No information is available on the validity of the job try-out or the behavioural consistency procedures for predicting performance in training programs.

For the next procedure, **reference checks**, the information presented in Table 1 may not at present be fully accurate. The validity studies on which the validity of .26 in Table 1 is based

were conducted prior to the development of the current legal climate in the United States. During the 1970s and 1980s, employers providing negative information about past job performance or behaviour on the job to prospective new employers were sometimes subjected to lawsuits by the former employees in question. Today, in the United States at least, many previous employers will provide only information on the dates of employment and the job titles the former employee held. That is, past employers today typically refuse to release information on quality or quantity of job performance, disciplinary record of the past employee, or whether the former employee quit voluntarily or was dismissed. This is especially likely to be the case if the information is requested in writing; occasionally, such information will be revealed by telephone or in face-to-face conversation but one cannot be certain that this will occur. However, in recent years the legal climate in the United States has been changing. Over the last decade, 19 of the 50 states have enacted laws that provide immunity from legal liability for employers providing job references in good faith to other employers, and such laws are under consideration in 9 other states (Baker, 1996). Hence, reference checks, formerly a heavily relied on procedure in hiring, may again come to provide an increment to the validity of a GMA measure for predicting job performance. In Table 1, the increment is 12%, only two percentage points less than the increments for the five preceding methods. Older research indicates that reference checks predict performance in training with a mean validity of .23 (Hunter & Hunter, 1984, Table 8), yielding a 9% increment in validity over GMA tests. But, again, these findings may no longer hold; however, changes in the legal climate may make these validity estimates accurate again.

Job experience refers to the number of years of previous experience on the same or similar job; it conveys no information on past performance on the job. In the data used to derive the validity estimates in these tables, job experience varied widely: from less than 6 months to more than 30 years. Under these circumstances, the validity of job experience for predicting future job performance is only .18 and the increment in validity (and utility) over that from GMA alone is only .03 (a 6% increase). However, Schmidt, Hunter, and Outerbridge (1986) found that when experience on the job does not exceed 5 years, the correlation between amount of job experience and job performance is considerably larger: .33 when job performance is measured by supervisory ratings and .47 when job performance is measured using a work sample test. *These researchers found that the relation is nonlinear:* Up to about 5 years of job experience, job performance increases linearly with increasing experience on the job. After that, the curve becomes increasingly horizontal, and further increases in job experience produce little increase in job performance. Apparently, during the first 5 years on these (mid-level, medium complexity) jobs, employees were continually acquiring additional job knowledge and skills that improved their job performance. But by the end of 5 years this

process was nearly complete, and further increases in job experience led to little increase in job knowledge and skills (Schmidt & Hunter, 1992). These findings suggest that even under ideal circumstances, job experience at the start of a job will predict job performance only for the first 5 years on the job. By contrast, GMA continues to predict job performance indefinitely (Hunter & Schmidt, 1996; Schmidt, Hunter, Outerbridge, & Goff, 1988; Schmidt, Hunter, Outerbridge, & Trattner,1986).

The amount of job experience does not predict performance in training programs teaching new skills. Hunter and Hunter (1984, Table 6) reported a mean validity of .01. However, one can note from this finding that job experience does not retard the acquisition of new job skills in training programs as might have been predicted from theories of proactive inhibition.

Biographical data measures contain questions about past life experiences, such as early life experiences in one's family, in high school, and in hobbies and other pursuits. For example, there may be questions on offices held in student organizations, on sports one participated in, and on disciplinary practices of one's parents. Each question has been chosen for inclusion in the measure because in the initial developmental sample it correlated with a criterion of job performance, performance in training, or some other criterion. That is, biographical data measures are empirically developed. However, they are usually not completely actuarial, because some hypotheses are invoked in choosing the beginning set of items. However, choice of the final questions to retain for the scale is mostly actuarial. Today antidiscrimination laws prevent certain questions from being used, such as sex, marital status, and age, and such items are not included. Biographical data measures have been used to predict performance on a wide variety of jobs, ranging in level from blue collar unskilled jobs to scientific and managerial jobs. These measures are also used to predict job tenure (turnover) and absenteeism, but we do not consider these usages in this article.

Table 1 shows that biographical data measures have substantial zero-order validity (.35) for predicting job performance but produce an increment in validity over GMA of only .01 on average (a 2% increase). The reason that the increment in validity is so small is that biographical data correlates substantially with GMA (.50; Schmidt, 1988). This suggests that in addition to whatever other traits they measure, biographical data measures are also in part indirect reflections of mental ability.

Biographical data measures are technically difficult and time consuming to construct (although they are easy to use once constructed). Considerable statistical sophistication is required to develop them. However, some commercial firms offer validated biographical data measures

for particular jobs (e.g., first line supervisors, managers, clerical workers, and law enforcement personnel). These firms maintain control of the proprietary scoring keys and the scoring of applicant responses.

Individuals who are assessed in **assessment centres** spend one to several days at a central location where they are observed participating in such exercises as leaderless group discussions
and business games. Various ability and personality tests are usually administered, and in-depth structured interviews are also part of most assessment centres. The average assessment centre includes seven exercises or assessments and lasts 2 days. (Gaugler, Rosenthal, Thornton, & Benson, 1987). Assessment centres are used for jobs ranging from first line supervisors to high level management positions. Assessment centres are like biographical data measures: They have substantial validity but only moderate incremental validity over GMA (.01, a 2% increase). The reason is also the same: They correlate moderately highly with GMA—in part because they typically include a measure of GMA (Gaugler et al., 1987). Despite the fact of relatively low incremental validity, many organizations use assessment centres for managerial jobs because they believe assessment centres provide them with a wide range of insights about candidates and their developmental possibilities.

Assessment centres have generally not been used to predict performance in job training programs; hence, their validity for this purpose is unknown. However, assessment center scores do predict rate of promotion and advancement in management. Gaugler et al. (1987, Table 8) reported a mean validity of .36 for this criterion (the same value as for the prediction of job performance). Measurements of career advancement include number of promotions, increases in salary over given time spans, absolute level of salary attained, and management rank attained. Rapid advancement in organizations requires rapid learning of job-related knowledge, and assessment center scores do appear to predict the acquisition of job-related knowledge on the job.

The **point method** of evaluating previous **training and experience (T&E)** is used mostly in government hiring—at all levels, federal, state, and local. A major reason for its widespread use is that point method procedures are relatively inexpensive to construct and use. The point method appears under a wide variety of different names (McDaniel et al., 1988a), but all such procedures have several important characteristics in common. All point method procedures are credentialistic; typically, an applicant receives a fixed number of points for (a) each year or month of experience on the same or similar job, (b) each year of relevant schooling (or each

course taken), and (c) each relevant training program completed, and so on. There is usually no attempt to evaluate past achievements, accomplishments, or job performance; in effect, the procedure assumes that achievement and performance are determined solely by the exposures that are measured. As shown in Table 1, the T&E point method has low validity and produces only a 2% increase in validity over that available from GMA alone. The T&E point method has not been used to predict performance in training programs.

Sheer **amount of education** has even lower validity for predicting job performance than the T&E point method (. 10). However, its increment to validity, rounded to two decimal places, is the same .01 as obtained with the T&E point method. It is important to note that this finding does not imply that education is irrelevant to occupational success; education is clearly an important determinant of the level of job the individual can obtain. What this finding shows is that among those who apply to get a particular job, *years of education does not predict future performance on that job very well.* For example, for a typical semi-skilled blue-collar job, years of education among applicants might range from 9 to 12. The validity of .10 then means that the average job performance of those with 12 years of education will be only slightly higher (on average) than that for those with 9 or 10 years on the job.

Many believe that **interests** are an important determinant of one's level of job performance. People whose interests match the content of their jobs (e.g., people with mechanical interests who have mechanical jobs) are believed to have higher job performance than with nonmatching interests. The validity of .10 for interests shows that this is true only to a very limited extent. To many people, this seems counterintuitive. Why do interests predict job performance so poorly? Research indicate that interests do substantially influence which jobs people prefer and which jobs they attempt to enter. However, once individuals are in a job, the quality and level of their job performance is determined mostly by their mental ability and by certain personality traits such as conscientiousness, not by their interests. So, despite popular belief, measurement of work interests is not a good means of predicting who will show the best future job performance (Holland, 1986).

Graphology is the analysis of handwriting. Graphologists claim that people express their personalities through their handwriting and that one's handwriting therefore reveals personality traits and tendencies that graphologists can use to predict future job performance. Graphology is used infrequently in the United States and Canada but is widely used in hiring in France (Steiner, 1997; Steiner & Gilliland, 1996) and in Israel, Levy (1979) reported that 85% of French firms routinely use graphology in hiring of personnel. Ben-Shakhar, Bar-Hillel, Bilu, Ben-Abba, and Plug (1986) stated that in Israel graphology is used more widely than any other

single personality measure. Several studies have examined the ability of graphologists and non-graphologists to predict job performance from handwriting samples (Jansen, 1973; Rafaeli & Klimoski, 1983; see also Ben-Shakhar, 1989; Ben-Shakhar, Bar-Hillel, Bilu, et al., 1986; Ben-Shakhar, Bar-Hillel, & Plug, 1986). The key findings in this area are as follows. When the assessees who provide handwriting samples are allowed to write on any subject they choose, both graphologists and untrained non- graphologists can infer some (limited) information about their personalities and job performance from the handwriting samples. But untrained non-graphologists do just as well as graphologists; both show validities in the .18-.20 range. When the assessees are required to copy the same material from a book to create their handwriting sample, there is no evidence that graphologists or non-graphologists can infer any valid information about personality traits or job performance from the handwriting samples (Neter & Ben-Shakhar, 1989). What this indicates is that, contrary to graphology theory, whatever limited information about personality or job performance there is in the handwriting samples comes from the content and not the characteristics of the handwriting. For example, writers differ in style of writing, expressions of emotions, verbal fluency, grammatical skills, and so on. Whatever information about personality and ability these differences contain, the training of graphologists does not allow them to extract it better than can people untrained in graphology.

In **handwriting** per se, independent of content, there appears to be no information about personality or job performance (Neter & Ben-Shakhar, 1989). For many people, this is another counterintuitive finding, like the finding that interests are a poor predictor of job performance. To these people, it seems obvious that the wide and dramatic variations in handwriting that everyone observes must reveal personality differences among individuals. Actually, most of the variation in handwriting is due to differences among individuals in fine motor coordination of the finger muscles. And these differences in finger muscles and their coordination are probably due mostly to random genetic variations among individuals. The genetic variations that cause these finger coordination differences do not appear to be linked to personality; and in fact, there is no apparent reason to believe they should be.

Table 1 shows that **age** of job applicants shows no validity for predicting job performance. Age is rarely used as a basis for hiring, and in fact in the United States, use of age for individuals over age 40 would be a violation of the federal law against age discrimination. We include age here for only two reasons. First, some individuals believe age is related to job performance. We show here that for typical jobs this is not the case. Second, age serves to anchor the bottom end of the validity dimension: Age is about as totally unrelated to job performance as

any measure can be. No meta-analyses relating age to performance in job training programs were found.

Finally, we address an issue raised by a reviewer. As discussed in more detail in the next section, some of the personnel measures we have examined (e.g., GMA and conscientiousness measures) are measures of single psychological constructs, whereas others (e.g., biodata and assessment centres) are methods rather than constructs. It is conceivable that a method such as the assessment center, for example, could measure different constructs or combinations of constructs in different applications in different firms. The reviewer therefore questioned whether it was meaningful to compare the incremental validities of different methods (e.g., comparing the incremental validities produced by the structured interview and the assessment center).

There are two responses to this. First, this article is concerned with personnel measures as used in the real world of employment. Hence, from that point of view, such comparisons of incremental validities would be meaningful, even if they represented only crude average differences in incremental validities. However, the situation is not that grim. The empirical evidence indicates that such methods as interviews, assessment centres, and biodata measures do not vary much from application to application in the constructs they measure. This can be seen from the fact that meta-analysis results show that the standard deviations of validity across studies (applications), after the appropriate corrections for sampling error and other statistical and measurement artefacts, are quite small (cf. Gaugler et al., 1987; McDaniel et al., 1994; Schmidt & Rothstein, 1994). In fact, these standard deviations are often even smaller than those for construct-based measures such as GMA and conscientiousness (Schmidt & Rothstein, 1994).

Hence, the situation appears to be this: We do not know exactly what combination of constructs is measured by methods such as the assessment center, the interview, and biodata (see the next section), but whatever those combinations are, they do not appear to vary much from one application (study) to another. Hence, comparisons of their relative incremental validities over GMA is in fact meaningful. These incremental validities can be expected to be stable across different applications of the methods in different organizations and settings.

Toward a Theory of the Determinants of Job Performance

The previous section summarized what is known from cumulative empirical research about the validity of various personnel measures for predicting future job performance and job-

related learning of job applicants. These findings are based on thousands of research studies performed over eight decades and involving millions of employees. They are a tribute to the power of empirical research, integrated using meta-analysis methods, to produce precise estimates of relationships of interest and practical value.

However, the goals of personnel psychology include more than a delineation of relationships that are practically useful in selecting employees. In recent years, the focus in personnel psychology has turned to the development of theories of the causes of job performance (Schmidt & Hunter, 1992). The objective is the understanding of the psychological processes underlying and determining job performance. This change of emphasis is possible because application of meta-analysis to research findings has provided the kind of precise and generalizable estimates of the validity of different measured constructs for predicting job performance that are summarized in this article. It has also provided more precise estimates than previously available of the correlations among these predictors.

However, the theories of job performance that have been developed and tested do not include a role for all of the personnel measures discussed above. That is because the actual constructs measured by some of these procedures are unknown, and it seems certain that some of these procedures measure combinations of constructs (Hunter & Hunter, 1984; Schmidt & Rothstein, 1994). For example, employment interviews probably measure a combination of previous experience, mental ability, and a number of personality traits, such as conscientiousness; in addition, they may measure specific job-related skills and behaviour patterns. The average correlation between interview scores and scores on GMA tests is .32 (Huffcutt et al., 1996).

This indicates that, to some extent, interview scores reflect mental ability. Little empirical evidence is available as to what other traits they measure (Huffcutt et al., 1996). What has been said here of employment interviews also applies to peer ratings, the behavioural consistency method, reference checks, biographical data measures, assessment centres, and the point method of evaluating past training and experience. Procedures such as these can be used as practical selection tools but, because their construct composition is unknown, they are less useful in constructing theories of the determinants of job performance. The measures that have been used in theories of job performance have been GMA, job knowledge, job experience, and personality traits. This is because it is fairly clear what constructs each of these procedures measure.

What has this research revealed about the determinants of job performance? A detailed review of this research can be found in Schmidt and Hunter (1992); here we summarize only the most important findings. One major finding concerns the reason why GMA is such a good predictor of job performance. The major direct causal impact of mental ability has been found to be on the acquisition of job knowledge. That is, the major reason more intelligent people have higher job performance is that they acquire job knowledge more rapidly and acquire more of it; and it is this knowledge of how to perform the job that causes their job performance to be higher (Hunter, 1986). Thus, mental ability has its most important effect on job performance indirectly, through job knowledge. There is also a direct effect of mental ability on job performance independent of job knowledge, but it is smaller. For nonsupervisory jobs, this direct effect is only about 20% as large as the indirect effect; for supervisory jobs, it is about 50% as large (Borman, White, Pulakos, & Oppler, 1991; Schmidt, Hunter, & Outerbridge, 1986).

It has also been found that job experience operates in this same manner. Job experience is essentially a measure of practice on the job and hence a measure of opportunity to learn. The major direct causal effect of job experience is on job knowledge, just as is the case for mental ability. Up to about 5 years on the job, increasing job experience leads to increasing job knowledge (Schmidt, Hunter, & Outerbridge, 1986), which, in turn, leads to improved job performance. So, the major effect of job experience on job performance is indirect, operating through job knowledge. Again, there is also a direct effect of job experience on job performance, but it is smaller than the indirect effect through job knowledge (about 30% as large). The major personality trait that has been studied in causal models of job performance is conscientiousness. This research has found that, controlling for mental ability, employees who are higher in conscientiousness develop higher levels of job knowledge, probably because highly conscientious individuals exert greater efforts and spend more time "on task." This job knowledge, in turn, causes higher levels of job performance.

From a theoretical point of view, this research suggests that the central determining variables in job performance may be GMA, job experience (i.e., opportunity to learn), and the personality trait of conscientiousness. This is consistent with our conclusion that a combination of a GMA test and an integrity test (which measures mostly conscientiousness) has the highest high validity (.65) for predicting job performance. Another combination with high validity (.63) is GMA plus a structured interview, which may in part measure conscientiousness and related personality traits (such as agreeableness and emotional stability, which are also measured in part by integrity tests).

Summary and Implications

Employers must make hiring decisions; they have no choice about that. But they can choose which methods to use in making those decisions. The research evidence summarized in this article shows that different methods and combinations of methods have very different validities for predicting future job performance. Some, such as interests and amount of education, have very low validity. Others, such as graphology, have essentially no validity; they are equivalent to hiring randomly. Still others, such as GMA tests and work sample measures, have high validity.

Of the combinations of predictors examined, two stand out as being both practical to use for most hiring and as having high composite validity: the combination of a GMA test and an integrity test (composite validity of .65); and the combination of a GMA test and a structured interview. (composite validity of .63). Both of these combinations can be used with applicants with no previous experience on the job (entry level applicants), as well as with experienced applicants. Both combinations predict performance in job training programs quite well (.67 and .59, respectively), as well as performance on the job. And both combinations are less expensive to use than many other combinations. Hence, both are excellent choices. However, in particular
cases there might be reasons why an employer might choose to use one of the other combinations with high, but slightly lower, validity. Some examples are combinations that include conscientiousness tests, work sample tests, job knowledge tests, and the behavioural consistency method.

In recent years, researchers have used cumulative research findings on the validity of predictors of job performance to create and test theories of job performance. These theories are now shedding light on the psychological processes that underlie observed predictive validity and are advancing basic understanding of human competence in the workplace. The validity of the personnel measure (or combination of measures) used in hiring is directly proportional to the practical value of the method—whether measured in dollar value of increased output or percentage of increase in output. In economic terms, the gains from increasing the validity of hiring methods can amount over time to literally millions of dollars. However, this can be viewed from the opposite point of view: By using selection methods with low validity, an organization can lose millions of dollars in reduced production. In fact, many employers, both in the United States and throughout the world, are currently using suboptimal selection methods. For example, many organizations in France, Israel, and other countries hire new employees based on handwriting analyses by graphologists. And many organizations in the United States rely solely on unstructured interviews, when they could use more valid

methods. In a competitive world, these organizations are unnecessarily creating a competitive disadvantage for themselves (Schmidt, 1993). By adopting more valid hiring procedures, they could turn this competitive disadvantage into a competitive advantage.

Appendix 5: A Description of GMA by one of its Proponents

Reference: http://www.performancegroup.co.nz

What is general mental ability?

General mental ability (GMA) is a term used to describe the level at which an individual learns, understands instructions, and solves problems. Tests of general mental ability include scales that measure specific constructs such as verbal, mechanical, numerical, social, and spatial ability. The overall score is considered the most important factor, explaining more variation in individual performance than specific abilities.

Why is GMA relevant to business?

General mental ability has been found to be the single best predictor of job performance across all organisations and positions; it accounts for approximately 29% of the variance in job performance. Studies have found that people with higher general mental ability acquire more job knowledge and acquire it faster. Higher levels of job knowledge lead to better performance. Objective assessments of general mental ability can significantly improve hiring decisions, staff retention and productivity.

How does GMA relate to work experience?

Many hiring decisions are strongly influenced by the extent of prior job experience. In fact, while job experience does influence job performance, its relationship is weaker than the relationship with general mental ability, and the influence of experience declines over time, unlike the relationship between job performance and general mental ability.

ROI of GMA testing

GMA tests are amazingly cost effective. You can dramatically improve the quality of your hiring decisions, avoid painful mistakes, all for a fraction of the cost of the new hire's first day at work.

Assessing likely future job performance

From a practical point of view, the most important property of a personnel assessment

method is predictive validity; that is, the ability to predict job performance and job-related learning.

In comparison to alternative personnel measures, general mental ability tests have the highest predictive validity, and the lowest application cost. Work samples and simulations are slightly more valid, but are expensive to set up. Structured selection interviews often contain job knowledge components, and are therefore less suitable for inexperienced or entry-level candidates. Assessment centre approaches are both much more expensive and also have less validity. The personality factor of Conscientiousness which describes motivation, personal organisation and focus, adds additional predictive power to tests of General Mental Ability.

Ultimately, the combination of a test of general mental ability, a personality test and a structured interview is the most cost effective approach.

Tests of General Mental Ability

Tests of general mental ability measure a wide variety of constructs, as well as overall cognitive ability.

Longer tests typically measure the following dimensions:

- General knowledge: The degree to which an individual has accumulated knowledge about diverse topics. Long-term memory.
- Social Intelligence: In both verbal and visual forms. Ability to evaluate social behaviour and likely outcomes, to apply standards for moral and ethical judgment.
- Arithmetic: Numerical reasoning and problem-solving abilities.
- Verbal concepts: Ability to categorise, conceptualise likenesses and differences, and to make subtle comparisons.
- Vocabulary: Extent of verbal concepts learned. Indicates communication skills, openness to information, ability to effectively use information.
- Coding: Adaptability and speed of learning
- Detail orientation: The ability to pick up on important details, using perceptual and analytical skills.
- Spatial rotation: Ability to visualise objects in different dimensions and perspectives.
- Spatial reasoning: Ability to see both the disparate parts of an object and how they fit together.

Shorter tests

Although, there are a wide variety of shorter instruments available for measuring general mental ability, the most effective, and widely used today, is the 12-minute Wonderlic Personnel Test. It incorporates a wide variety of problem types including conceptual comparisons, word and sentence meanings, deductive logic, sequential reasoning, detail matching, analysis of geometric figures, and story problems requiring mathematical solutions. Test takers must enter their answers so that, in contrast to the usual multichoice format, there is a richness of information available for evaluation. The applicant's test score can be compared against minimum recommended scores for various occupational groups.

The Wonderlic Personnel Test provides quantitative insight into how easily individuals can be trained, how well they can adjust and solve problems on the job, and how satisfied they are likely to be with the demands of the job. Higher scoring individuals will gain more from formalised training, and are more likely to effectively learn from on the job experience. In contrast, lower scoring individuals will require more detailed and explicit instruction, hands on practice, more time and repetition, and close supervision.

Tests of Critical Thinking

For managers the ability to critically evaluate business propositions and the conclusions drawn by staff is vital. The Watson Glaser is the most widely used test of critical thinking. It assesses ability on different types of critical thinking. Given a set of information and a conclusion, to assess;

- what hidden assumptions have been made
- what inference can be taken - the relative truth or falsity of the conclusion
- whether the conclusion logically follows from the facts
- the relative strength or weakness of an argument and conclusion

Scores can be compared with similar occupational groups and management levels

Appendix 6: Calculation of Statistical Limits for the IQ index and the Overall Index as given in Table 10.4

The IQ Index Values are given in the column X below. X_{ave} is the average value =

X	$(X - X_{ave})$	$(X - X_{ave})^2$
6.6	0	0
6.5	0.1	0.01
6.6	0	0
5.9	0.7	0.49
6.9	0.3	0.09
6.4	0.2	0.04
6.6	0	0
7.6	1.0	1
$\Sigma = 53.1$		$\Sigma_a = 1.63$
Ave = 6.6		

S = Standard Deviation = $\sqrt{\Sigma_a/(n-1)} = 0.48$

Standard Error = $S/\sqrt{n} = 0.48/\sqrt{8} = 0.48/2.82 = 0.17$

From statistical tables for the Student-t population,

For 95% confidence

$T_{0.025} = 2.365$

$M_{population} = 6.6 +/- 2.365(0.17)$

$= 6.6 +/- 0.404$ or +/- about 6%

Hence the mean, M for the population of 31, derived from

the sample of 8 is between 7 and 6.2

The values for Experience, Qualifications and Health are for the entire population, and hence have no limits of error. The limits of error for the combined arithmetic Index are one quarter of those for the IQ Index, at about +/- 2%. This can be demonstrated as follows:

Assume we have four values in the index, 2, 2, 2, 2. Assume that one can change by a full 50%. The we have 1.9, 2, 2, 2 and 2.1, 2, 2, 2. The averages for these two indices are then 1.975 and 2.025. So, the limits have reduced by 0.01 to 0.025 or by **¼.**

Appendix 7: CV of E. A. Bradley, 2020

Personal Details

Name: Edgar Anthony Bradley

Date of Birth: 19 May 1942

Marital status: Married, four children, five grandchildren

Married: 1968

Dependents: Wife, one daughter

- Registered Professional Engineer, Engineering Council of South Africa, 1989. Registration no. 890105

Email addresses: edgar.bradley@telkomsa.net

engineer@bradleyce.com

Website: www.bradleyce.com

Telephones: +27 11 465 0275

+27 83 292 7733

Address: 1025 Villa Quattro

Poplar Avenue

Craigavon

Johannesburg

South Africa

Postal Address: Postnet 773

Private Bag X153

Bryanston

2021

South Africa

Publications

2016: Author of the book Reliability Engineering – A Life Cycle Approach, published by CRC in the USA.

Work Experience

2007- 2019: Consulting Mechanical Engineer specializing in RAM (Reliability, Availability and Maintainability). Training offered extensively to the petrochemical industry in the Middle East and in South Africa for the past seven years. Organisation of conferences on Engineering Topics eg Coal Milling Plant. Consulting to various organisations in South Africa, Zimbabwe and Botswana on RAM. Clients include petrochemical companies, power utilities, mines, earthmoving equipment manufacturers, munitions manufacturers, a hotel group and metal refineries. Presentation of courses in South Africa and the Middle East.

Courses presented in the following subjects:

- Principles of Management
- Shutdowns, Turnarounds and Outage Management
- Industrial Marketing
- Incident Investigation and Root Cause Analysis
- Project Management
- Finance for non-financial managers
- Maintenance Engineering and Management
- Reliability Engineering
- Benchmarking of company performance
- Human Capital Evaluation
- All manner of mechanical engineering subjects, including
    - Safety Valves – design, maintenance and testing
    - Heat Exchangers – design and maintenance
    - Boilers – design, maintenance and operation
    - Steam Traps – selection and maintenance

- Pumps – type selection, maintenance and operation
- Compressors – design, type selection, maintenance and operation
- Mechanical Engineering principles for non-mechanical engineers
- Pressure vessels especially ASME VIII
- Technical writing including reports
- Lubrication
- Condition monitoring – oil analysis, vibration monitoring and thermography
- Maintenance planning
- The Reliability Engineer – his functions in industry
- Certified Reliability Engineer
- Stores management and material cataloguing
- Root Cause Analysis and Incident Investigation
- History of Engineering
- Total Productive Maintenance
- Reliability Centred Maintenance
- Facilities management – hotels, offices universities etc
- Maintenance Auditing
- Stores Auditing

1976 - 2006: Employed by Eskom, the South African power utility.

1988 – 2006: RAM engineer. Duties included design of a RAM department, with both staffing and duties spelled out. Staff of four. Activities included RAM requirements for specifications, studies to determine optimal plant configurations, and RCM Studies (Reliability Centred Maintenance). Scope covered internal consulting on RAM matters to power stations and to distribution and transmission divisions. Several years were spent in the Nuclear Engineering section. Interests covered mechanical, electrical and human reliability.

In the latter connection, the writer was responsible for the design and management of the Operators' Challenge, an initiative to increase power station operator reliability through motivation. The challenge was institutionalized and the internationalized with competitions between Eskom and the Moscow utility. For his efforts in the area he and his team were awarded the Eskom Chairman's Award in 1999

The writer was also responsible for the introduction and computerization of the Paired Comparisons methodology for Probabilistic Risk Analysis.

The writer was also allowed by Eskom to consult on RAM matters to outside organisations such as mines, chemical plants, military contractors and the like.

1978 – 1987: Boiler Project Engineer, responsible for the Boiler contracts at Matla and Kendal power stations. Duties included tender report preparation, site visitation and liaison, regular project meetings with contractors, surveillance and management of budget, schedule and specifications for the contract.

1976 - 1977: Specialist Engineer, responsible for coal milling plant and thermal insulation. Duties included specification writing, plant testing, and supplier evaluation. (the writer's specification for thermal insulation was still being used by the utility and by supplier industry as late as 2006).

2000 - 2008

The writer also served as industry representative on the board of SAMA, the Southern African Maintenance Association. (Now called SAAMA). He was elected President of that organisation twice during this period. He was also jointly responsible for the design of the SAMA audit, used to assess maintenance practices both at various companies in South Africa, Namibia, Botswana and Australia. This audit has now been applied at over 40 sites and has been calibrated internationally to ensure its quality.

1976 -2017

The writer has also served part-time on the staff of the University of the Witwatersrand in the Department of Mechanical Engineering, lecturing students on inter alia, Reliability Engineering, Maintenance Engineering, Project Management, Principles of Management and Industrial Marketing.

He has also lectured at the University of Pretoria in a similar capacity.

He has also lectured at North West University in Reliability Engineering and Systems Engineering

He has lectured Quality at the Namibian University of Science and Technology, Windhoek, Namibia

1975

Worked as Plant Engineer at Hendlers Limited, a metal pressing company in Boksburg, South Africa. Responsible for maintenance of the entire plant. Attained the practical experience necessary to write the Government Certificate of Competency.

1974

Completed studies for the MBA at Cranfield Institute of Technology, UK

1972 – 1973

Employed as Technical Manager at IRD in Boksburg, South Africa. IRD was a manufacturer of cryogenic equipment to the liquid gas industry in South Africa, Angola, Mozambique, Portugal and New Zealand. The writer was involved in the design of road tankers, pressure vessels and pumping systems for liquid oxygen, nitrogen and carbon dioxide. He gained experience of stainless steel and aluminium fabrication, of welding and of quality control. Projects were designed, manufactured, sent to site and commissioned, with common oversight by the writer.

1969 – 1971

Employed as Engineering Manager at IDS, a Johannesburg based engineering consultant. The work was usually of a fairly low grade, many jobs being contract drafting rather than design, but there were exceptions such as aluminium conductor area optimizations (in the era before high-speed computing).

1968

Complete the MSc. In Mechanical Engineering at the University of Akron, Ohio USA.

1966 – 1967

Employed as an Engineer in the Pipework Engineering Department of Stewarts and Lloyds in Johannesburg, South Africa. Stress analysis of high-temperature, high-pressure pipework systems for power stations e.g., Arnot power station. Design and site installation of piping systems for mineral processing plants e.g., Buffelsfontein uranium extraction plant.

1965

Compulsory military service. Commissioned as a second lieutenant in a Field Workshop Squadron in Bethlehem, South Africa. In charge of maintenance planning for hard and soft-skinned vehicles, small arms and artillery. (This service was followed by nine years of part-time service during which the writer rose to the rank of major).

1964

Graduate from the University of the Witwatersrand, Johannesburg, South Africa with a B.Sc. in Mechanical Engineering

Non-work-related Interests, past and present

- International and local travel, especially by 4x4
- Ecotourism

- Car and Motorcycle restoration –
  Former projects: 1939 MG, 1958 Ducati, 1958 Pegaso
  Current projects: 1958 Capriolo
- Badminton
- Church work

Qualifications

- High School Matriculation Certificate, Germiston High School, South Africa, 1959. First Class Pass, Distinction in Physical Science. Prizes for being top student in Forms III and IV.
- Bachelor of Science in Mechanical Engineering, University of the Witwatersrand, Johannesburg, South Africa, 1964
- Master of Science in Mechanical Engineering, University of Akron, Ohio, USA, 1969
- Master of Business Administration, Cranfield Institute of Technology, Bedfordshire, UK, 1974
- Government Certificate of Competency (Factories, Mechanical), South Africa, 1976

Membership of Professional Institutions

- Registered Professional Engineer, Engineering Council of South Africa, 1989. Registration no. 890105
- Member, South African Institute of Industrial Engineers, 1974. Membership no. 03906
- Member South Africa Institution of Mechanical Engineers, 1974
- Member, New York Academy of Sciences, 1996
- Member, Mensa South Africa, 2004
- Member, Southern African Maintenance Association, 2000.
- Member, Society for Maintenance and Reliability Professionals, USA, 2004. Registration No. 04040

Positions Attained outside of normal work

- Commission, South African Defence Force, 1968. Rank on retiring: Major
- Part-time Lecturer, University of the Witwatersrand, 1976- 2019
- Accredited Auditor, Southern African Maintenance Association, 2002
- President, Southern African Maintenance Association, 2002

- President, Southern African Maintenance Association, 2006
- Chairman, Homeowners Association, Villa Quattro Complex, 2006 - 2015

Other Courses attended

- Advanced System Reliability Engineering, JBF Associates, Knoxville, Tennessee, USA, 1988
- Institute of Advanced Motorists of Southern Africa, 1998
- Wits Language School, Russian for Beginners, University of the Witwatersrand, 2001
- ISO 9001:2000 Internal Auditor Qualification, 2002
- Repairable Systems Reliability, Finn Jensen Reliability Consultancy, Denmark
- Certified Maintenance Manager (Qualification for Hotel and Facilities Management). American Hospitality Institute, Orlando, Florida USA

Scholarships Awarded

- Norton Abrasives Scholarship in Mechanical Engineering, University of the Witwatersrand, 1964
- Goodyear Fellowship for study at the University of Akron, 1969
- SEIFSA Scholarship for study at Cranfield Institute of Technology, 1974