Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.8, No.22, 2017

Scientific Research, Writing, and Dissemination (Part 1/4): Boosting Research Quality

Diana Starovoytova
School of Engineering, Moi University P. O. Box 3900, Eldoret, Kenya

Abstract
This-is the-first-piece of a-tetralogy on Scientific-Research, Writing, and Dissemination. Many-researches have published articles and, even, books, on-Scientific-Research; however, at-the-time of this-study, none of-them articulated Kenyan-scenario, in-engineering-context. Research is one of the-core-functions of any-university-system; hence its-quality is-paramount. This-paper had-*critically* examined the-wider, local-institutional-context, of the-current-practice, and trends, in-scientific-research. A-survey (sample-size of 15 senior-engineering-faculty), observations, interviews and a-document-analysis-instruments, were utilized. The-main-findings of this-study were: (1) 73% indicated, that getting sufficient and trustworthy background-information was the-biggest-challenge (e.g. for identifying reliable-sources from-the-Internet); and (2) 64% pointed-out on the-problem of identification representative-sample-size, in their-research. In-addition, some-misconceptions, regarding: (1) the-quality-aspect of research; and (2) qualitative-research and its-value to-engineers-researchers; were-identified. Primarily, this-work was intended as a-contribution to a-heated ongoing debate, presenting a-basis for reflection and supported-argument, on the-quality of research, in the-institution. Besides, it provided a-rigorous-selection of helpful and enlightening-insights on the-issues, relevant to-the-quality of research, such-as: The-overall-process of Research, including specifics on the-Research in-Engineering; Assessment-models of Research-quality; Qualitative-research *vs.* Quantitative-research; Western-dominance in-Research; Reviewing of literature/Document-Analysis; Evaluation and selection the most-appropriate and reliable-sources; Sample-size and sampling-techniques; and Good-research practice (*often overlooked*), including ethical-issues, among-others. Several recommendations also-offered, on how to-improve, the-current-situation.
Keywords: research types; quality; engineering; choosing sources; literature review, Internet.

1. Introduction.

1.1. Research and its-output.

In a-global, knowledge-driven-economy, technological-innovation, is a-key to a-nation's prosperity and security; to-achieve competitiveness, long-term productivity-growth, and the-generation of wealth (Council on Competitiveness, 2005). One of the-most-decisive-elements of the-innovation-process is the-long-term *research*, required to-transform new-knowledge-generated, by-fundamental scientific-discovery, into the-innovative new-products, processes, and services, required-by-society. Research, is also directly affecting the-development of any-country (African Development Bank, 2007; German & Stroud, 2007; Sumberg, 2005). Sub-Saharan-Africa has a low-scholarly-publishing-rate, when compared to other-regions, both; developed and developing (World Bank, 2005; Hassan, 2001). Moreover, the-index of scholarly research has declined in-terms of output-quality, and regularity of publications (Duderstadt, 2009). This may-be interpreted as a-declining-global-competitiveness of sub-Saharan-African-science, as a-whole, hence a-structural-problem in the-regional-system of innovation.

Furthermore, unstoppable-flood of articles is published, all-over-the-globe; yet, the-majority of them, adding very-little, or no-scientific-advancement; rarely of value and relevance, for industrial- innovations; display an-intellectually-average-standard; and hardly-contribute to any-progress, in-science and engineering. Collectively or individually, this points-out at *poor-quality of research* and/or mediocre-scientific-writing; according to Gerhard Frohlich: 'Most scientific-publications are utterly redundant, mere-quantitative 'productivity'.

1.2. Research: its essence, purpose, types and approaches.

The-term *research* is originated from the French '*recherche'*, meaning 'to go about seeking'; the earliest-recorded-use, of the-term, was in 1577 *(Encyclopedias Britannica). Research* can-be considered as 'a-process of systematic and focused-investigation' *(Shuttleworth, 2008),* in-order, to-develop or contribute to generalize-able-knowledge, on a-specific-topic or issue. Research-studies pose specific-questions that are clear, focused, multifaceted and, yet, concise. John Creswell pointed-out that research consists of three- steps: (1) Pose a-question; (2) Collect data, to-answer the-question; and (3) Present an-answer, to the- question (Creswell, 2008).

Research is-used to: (1) Establish or confirm-facts; (2) Reaffirm the-results of previous-works; (3) Solve new or existing-problems; (4) Support-theorems; and (5) Develop new-theories. A-research-project may-also be an-expansion on-past-works, in-the-field; to-test the-validity of instruments, procedures, or experiments; besides, research may-replicate elements of prior-projects, or even, the-project, as-a-whole (Hong, 2005).

According to Mammela (2006), motivations for conducting-research are: (1) Internal-drive (Research-interest; New-Areas Exploration; Cross-Disciplinary-Research (sense of achievement, fulfillment, and curiosity)); (2) Strong-ambition (self-expectation); (3) External-drive (Degree and diploma, Parents, teachers, friends; Peer-pressure (sense of honor and responsibility); (4) Professional-Success and recognition; and (5) Knowledge discovery/invention, among-others. Research also-offers many satisfactions, besides the-exhilaration of discovery; it can-have a-direct and immediate-impact on the-lives of people, throughout the-world.

Besides, Hong (2005), stated, that the-approaches to-research depend on epistemologies, which vary-considerably both; within and among humanities, sciences and engineering. There-are several-forms of research: scientific, humanities, artistic, economic, social, business, marketing, practitioner-research, life, technological, and engineering, among-others. Besides, the-research-process takes three-main-forms; the boundaries between-them, however, may-be-vague: (1) *Exploratory research*, which helps to-identify and define a-problem or question; (2) *Constructive research*, which tests-theories and proposes-solutions, to a-problem or, question; and (3) *Empirical research*, which tests the-feasibility of a-solution, using empirical-evidence (experiment or observation).

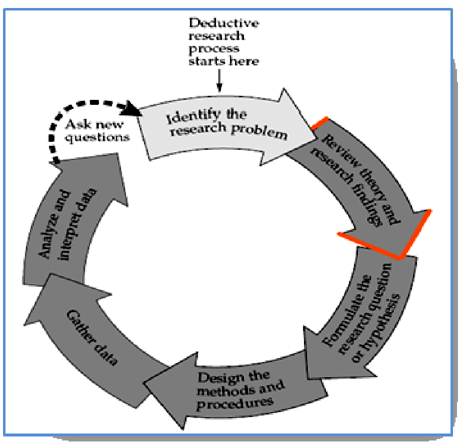
Other-classifications exist, where the major-purpose of *descriptive research* is description of the-state of affairs, as it exists, at-present. The-main-characteristic of this-method is that the-researcher has-no-control, over the-variables. In *analytical research*, on the-other-hand, researcher makes a-critical evaluation of the-material, by analyzing facts and information, already-available. *Applied Research* is to-find a-solution, for an-immediate-problem, facing a-society or an-industrial/business organization, whereas *Fundamental* or *Pure Research* is mainly-concerned with generalizations and concentrates on the-formulation of a-theory. 'Gathering knowledge for-the-sake of knowledge' is termed 'Pure', 'Basic' or 'Fundamental' research. *Quantitative research,* on-the-other-hand, is applicable to phenomena that can-be-expressed, in-terms of quantity, *Qualitative research* is-concerned with-qualitative phenomenon. *Conceptual research* is that related to-some-abstract-idea(s) or theory, while *Experimental (empirical) research* relies on research, alone (Camarinha-Matos, 2016).

Research-objectives fall-into the-following broad-groupings: (1) To-gain-familiarity with a-phenomenon or to-achieve new or deeper-insights into-it (known as *exploratory* research-studies); (2) To-determine the-frequency with-which something-occurs or with-which it-is associated with something else (known as *diagnostic* research-studies); and (3) To-test a-hypothesis of a-causal-relationship, between variables (known as *hypothesis-testing* research-studies). Basic-research, for-example, (as opposed to applied-research) are intended for: documentation, discovery, interpretation, or the-research and development (R&D) of methods and systems, for the-advancement of human-knowledge (Gustafsson *et al.,* 2006). Moreover, the-purpose of the-original-research is to-produce *new*-knowledge, rather than to-present the-existing-knowledge, in a-new-form (reviewed, cataloged, tailored or re-packaged).

The-research-process, in-essence, however, is the-same, whether the-subject-matter of the-research is pure-science, medicine or history. The-following rather-expansive-definition, given by Graziano & Raulin (2004) sums-up the-breadth of the-scope of the-research-process:

> Research is a-systematic-search for information, a-process of inquiry. It can be carried out in libraries, laboratories, schoolrooms, hospitals, factories, in the pages of the Bible, on street corners, or in the wild watching a herd of elephants.

Two-fundamentally-different-approaches, to-conduct a-research, are-existing; Figure 1(a) shows the deductive-research process-structure, while Figure 1(b) –inductive-approach to research.



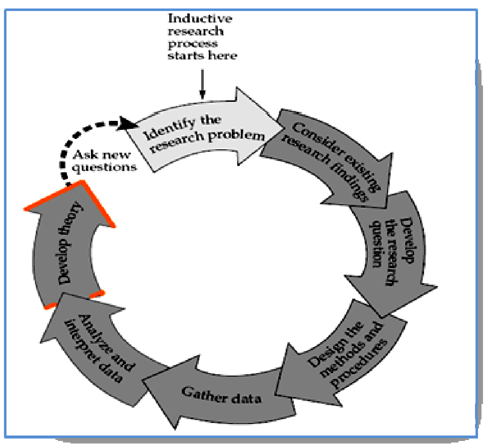


Figure 1(a): Deductive-approach Figure 1(b): Inductive-approach
Source: Adopted from Creswell (2007).

In-Figure 1(a), after identifying the-research-problem, a-researcher begins with a-theory and then, gathers evidence, or data, to-assess, whether the-theory, is correct. This-type of research is *deductive,* because a-researcher is moving, from a-known or assumed-position, supported by a-theory, to-the-particulars of the-data. Alternately (see Figure 1(b)), a-researcher suspends-judgment, in-beginning of their-work, and develops a-plan, for gathering-data, which is framed, around the-foundation of a-research-question. After the-data are gathered and examined, theories are developed, in response to-what the-data-reveal. This-type of research-process is *inductive,* because the-researcher is moving from the-specifics of the-data, to the-more-general-explanation of theory. Both-models are circular and cyclical; each of the-steps must-occur, for the-research-process, to-be-complete. The-steps are not an-independent-activities, but, rather, are-inter-dependent (Creswell, 2007).

Besides, to-be-termed scientific, a-method of inquiry (research) must-be-based on gathering observable, empirical and measurable-evidence, subject to specific-principles of reasoning (*Armstrong & Sperry, 1994).* The-scientific-approach attempts to-minimize the-influence of the-researchers'-bias on the-outcome of an-experiment. For-example, a-researcher may have a-preference for one-outcome or another, and it-is-important that this-preference *not* bias the-results or their-interpretation. Boghetto (2003), pointed-out, that 'despite extensive-discussion, universal-agreement about the-exact-meaning of the definition of scientifically based-research, remains elusive'. For-instance, according to-Lynch (2013):

> *Scientific*-research is the-process of: (1) developing an-empirically-answerable-question; (2) deriving a falsifiable-hypothesis, derived from a-theory that purports, to-answer the-question; (3) collecting (or finding) and analyzing empirical-data, to-test the-hypothesis, (4) rejecting or failing to-reject the-hypothesis, and (5) relating the-results of the-analyses back-to-the-theory, from-which, the-question, was-drawn.

On-the-other-hand, according to Zucker (2008), *scientifically based-research* is: (a) research, that involves the-application of rigorous, systematic, and objective-procedures, to-obtain reliable, relevant and valid-knowledge; and (b) includes research that: (1) employs systematic, empirical-methods, that draw-on observation or experiment; (2) involves rigorous-data-analyses, that are adequate to-test the-stated hypotheses and justify the-general-conclusions, drawn; (3) relies on measurements or observational- methods, that provide reliable and valid-data; (4) is evaluated using experimental or quasi-experimental designs; (5) ensures that experimental-studies are presented in sufficient-detail and clarity, to-allow for replication or, at a-minimum, offer the-opportunity to-build systematically on their-findings; and (6) has been-accepted by a-peer-reviewed-journal or approved by a-panel of independent-experts, through a-comparably rigorous, objective, and scientific-review.

Based on the-above-definitions of scientific-research, there-are, however, at-least, 3 things, which do *not* constitute scientific-research: (1) A-literature-review, *alone* (Although reviewing and synthesizing literature is an-important-part of the-research-process, it-is-not, in-itself, a-research. The-process of reviewing-literature does-not-add to the-body of knowledge, unless the-literature is critically-evaluated, incorporating author(s)' unique-input; (2) Theory-construction or forging-links, between-theories or perspectives, in the-absence of empirical-data (Although the-process of modifying and linking theories is an-important-part of research, it-is-not a-research, by-itself; these-processes are logical, but not empirical-processes, they may-be-contributing to-the-understanding of the-subject-matter, but do-not-add anything-new; and (3) Collection and analysis of data, without theoretical-grounding (i.e., having no-research-question(s)) and offering no-explanation of the-data (Data-collection is an-incredibly-important, central-part of research; without data, no-research could-be-done. However, data-collection, alone, is not a-research, because there-is-no theory-driven-question, being asked nor answered (Lynch, 2013).

On-the-other-hand, one-activity that may-not-appear to-be a-research, but in-fact is, is replication. *Replication* is the-process of repeating an-experiment or study, to-verify the-original-findings. Technically speaking, true-replication involves imitating a-previous-study, exactly; that is, using the-same data-collection and analysis-methods, and observing whether the-original-research-results hold (Lynch, 2013). In Toxicology, for-example, to-accept a-certain-finding, the-same-research must-be replicated, exactly, but in-different-parts of the-world, and by-different-researchers; and in-case the-results-obtained are in-agreement, the-finding is accepted, by scientists-toxicologists. Replication is an-important-part of the-scientific-process, although it receives very-little-attention, in contemporary science-literature; moreover, it-is very-difficult to-get such-work published.

This-paper is focused on-scientific-research, in-general, and engineering-research, in-particular. Besides, in the-following-synopsis, *replication* is excluded, from-consideration.

1.3. Quality of research

Quality, by-far, is not a-straightforward-concept. According to Harvey & Green (1993), there-are a-number of different-concepts of quality, such-as: The-notion of excellence; Value for money; Stakeholder satisfaction; and Fitness for purpose, among-others. The Oxford English Dictionary (OED) defines-it as the-nature or standard of something, as-measured, against other-things of a-similar-kind, and especially, the-degree of excellence, itpossesses.

In the-academic-environment, there-is widespread agreement that quality involves adherence to key-principles, such as: (1) Intellectual-rigor; (2) Accurate-recording and honest-reporting of results; and (3) Integrity, in recognizing the-work of other researchers (Shavelson & Towne, 2002).

According to Boaz & Ashby (2003), high-quality-research is: (1) *Systematic*: It-means that research is-structured with specified-steps, to-be-taken, in a-specified-sequence, in accordance with the-well-defined-set of rules; (2) *Logical*: This-implies that-research is-guided, by the-rules of logical reasoning, and the-logical-process of induction and deduction, are of great-value, in carrying-out-research; (3) *Empirical:* It-implies that-research is-related, basically, to-one or more-aspects of a-real-situation and deals with concrete-data, that provides a-basis, for external-validity to-research-results; and (4) *Replicable:* This-characteristic allows research-results to-be-verified, by replicating the-study, and thereby building a sound-basis for decisions.

Quality research most-commonly refers to the-scientific-process, encompassing all-aspects of study-design; in-particular, it-pertains to the-judgment, regarding the-match between the-methods and questions, selection of subjects, measurement of outcomes, and protection-against: (1) systematic-bias; (2) nonsystematic-bias; and (3) inferential-error (Lohr, 2004).

While research-quality pertains to the-scientific-process, evidence-quality pertains-more to-a-judgment regarding the-strength and confidence, one-has, in the-research-findings, emanating from the scientific-process (Mosteller & Boruch, 2002; Shavelson & Towne, 2002). According to Lohr (2004), 'The level of confidence one might have in evidence turns on the underlying robustness of the research and the analysis done to synthesize that research'. Commonly cited-criteria, for evaluating systems, to-rate the-strength of bodies of evidence include (West *et al.,* 2002): (1) *Quality:* the-aggregate of quality-ratings for individual-studies, predicated on the-extent to-which bias was-minimized in the-study-designs; (2) *Quantity*: the-number of studies, the-sample-size, the study design's statistical-power, to-detect meaningful effects, and magnitude of the-effects, found or the-effect-size; and (3) *Consistency*: for any-given-topic, the-extent to-which similar-findings are-reported, using similar and different-study-designs.

In-this-study, quality of scientific-research is the-main-subject of interest.

1.4. Problem statement and purpose of the-research

According to UNESCO (2010), worldwide, 77% of researchers are-concentrated only-in-5-countries: USA (20%), EU (20%), China (20%), Japan (10%), and Russia (7%); with a-strong-migration-pattern, from South to-North. Sub-Saharan-Africa has 113 researchers, per-million-population, compared to China's 454, India's 151, and Newly Industrialized Contries 595 (Ogbu, 2004). Kenya, on the-other-hand, has about 4,000 researchers (representing a-microscopic-fraction of the-global-research-force), which equals to-only 100 researches per-million-inhabitants (Science in Africa, 2011).

On-the-other-hand, research is not-finished, until it-is published. Absolute-volume of published-papers is one-indicator of research-activity and, indirectly, of research-capacity of a-country. Research is also-directly-contributes to the-overall-reputation, of affiliated-institution. Asongu (2014), for- example, cited the 2013 Shanghai-Academic-Rankings of World-Universities (ARWU), which has-been annually-reporting the Top 500 World-Universities, and is acknowledged as the-most-trustworthy, in the-rankings of world-universities. ARWU, (2013) pointing-out the-prevailing-depiction of developed- countries *vis-à-vis* their-developing-counterparts. Notwithstanding many-leading university-research projects, in-developing-countries; such-as: Chile's accomplishments, in-astronomy; India's achievements in computer-science and mathematics; China's work in seismology; and efforts in Africa, to-establish national R&D centres of excellence; among-others, UNESCO report (2006), highlights the-dominance of North America, Western-Europe, Australia, Japan and China; the catch-up-effort of Latin-America and depressed representation of the-Middle-East, South-East-Asia, *Africa*, and Eastern-Europe and Central-Asia.

The-leading African-countries, by-publication-output are: South-Africa, Egypt, Nigeria, Tunisia, Algeria and Kenya. Four of these are *also* leading-countries, in-terms-of GDP (Adams *et al,* 2010). According to *Elsevier'* Database for Science, Social Science and Humanities, the-number of publications in the-three-leading African-countries are: South Africa - 8,805; Nigeria - 3,952; and Kenya - 1,238 scientific-publications. Moreover, according to the World Bank Group report (2017) on 'Improving the Quality and Quantity of Scientific Research in Africa', the-following was pointed-out that: (1) STEM research makes-up *only* 29% of Africa's total research-output, despite the-need for more-research on energy, transport, light-manufacturing, and the-extractives; and (2) the-pace and *quality* of STEM-research need-to-be stepped-up further. STEM-research makes-up *only* 29% of Sub-Saharan Africa's output, leaving a-gap, in-many-countries' ability to-enhance-sectors like energy, transport, manufacturing and the-extractive- industries. Yet, progress in these-sectors, could-significantly-transform Africa's economies and help reduce poverty (The World Bank Group, 2017).

In-academia, quality-research research-visibility have-largely been-seen from the-point of scholarly-publications and their-citations, which-appear, in-peer-refereed-journals, indexed by popular/ reputable international-databases, such-as: Thompson Reuters Web of Science (WoS), Scopus, and Google Scholar, to some-degree.

Moreover, according to-recent-study, at-Kenyan-context, by Ocholla's *et al* (2016), on Moi University (MU)'s research-publications, indexed in WoS (Web of Science) and Scopus, between 2003 and 2013, the-results-reveal that: (1) the-publications, of most of the-researchers (approximately 70%), were *not* indexed in the-databases; (2) of the 780 academic/researchers of the-institution, 964 and 645 papers were-indexed, in Scopus and WoS, respectively; (3) the-per-capita-publication in WoS (for MU) was 0.8, and 1.2 in Scopus; (4) The most-important (highest-cited) research at MU (2003-2013) was conducted in the-field of Medicine, followed by the-Environmental-Sciences; while (5) Engineering-field-contributed *only* 13.9% (134 publications), with the-highest-field-researcher having *h-Index,* of WoS-14; and Scopus-15.

Furthermore, at a-local-context, according to Starovoytova *et al.* (2015):

> …there is a-deficit (of minimum-216%) of Engineers, in-Kenya. Huge-mismatch between supply and demand of Engineers, in Kenya, is apparent, which, in-turn challenges Kenya's higher engineering education-system. This-means that there is an-urgent-need, for developing a significant-mass of Engineers and Technologists, to-reduce the-existing-deficit-gap.

On-the-other-hand, research-scholars, particularly-those, engaged in-engineering-research, are facing several-problems. Some of the-main-problems, leading to a-great-impediment for research-scholars, across the-world; are as-follows: (1) The-lack of a-scientific-training in the-methodology of research; (2) Insufficient-interaction, between-the-university research-departments, on-one-side, and industries and research-institutions, on- the-other-side; (3) Deficiency of Code of Conduct, for-researchers; and (4) Prevalent inter-university and inter-departmental-rivalries (Seyed *et al.,* 2004).

In the-view of the-substantiation, presented-above (shortage of engineers and researchers; poor-research-quality, contributing to high-rejection-rates; low-visibility of publications; and lack of training on scientific-writing, among-others) this-study, therefore, surveys the-opinions, about scientific- research and its-quality, at the-institutional-context, among engineering-faculty. Besides, the-authors strived to add to-the-body of knowledge and present a-practical-guide for researchers, especially, those, at the beginning of their scientific-writing-experiences. This will-enable-them to-increase their-research output and quality; and moreover, help policy-makers take-more-specific-steps to-foster research capabilities. Furthermore, this-paper intends to-contribute (in its-small-way) to a-continuous-deliberation, about quality of scientific-research, by-academic-faculty.

The-following relevant-issues are-also-presented (in-different-level of detail): The-overall-process of Research, including Research in Engineering; Assessment-models of research-quality; Western dominance in-research; Reviewing of literature/Document-Analysis; Evaluation and selection the-most appropriate and reliable-sources; Qualitative-research *vs.* Quantitative-research; Sample-size and sampling- techniques; and Good-research practice, including ethical-issues, among-others.

2. Materials and Methods.

2.1. Focus and design of the-study.

The-main-focus, of this-paper, is *Scientific-Research*, as-shown in-Figure 2. Research, as it-appears from the-Figure, is just a-single-component, in a-line of coherent-processes, leading-to publishing and dissemination, of research-findings; nevertheless it-is an-*opening*-process, therefore, it is only-logical, to-presume, that the-publication of a-high-quality-article can-*only*-come, from a-quality-research, hence this-step deserves a-special-attention. Secondly, the broad-coverage, presented below, is meant to-appeal to-all-disciplines; additional-emphasis, nevertheless, will-be-put-on the-research, in-engineering.

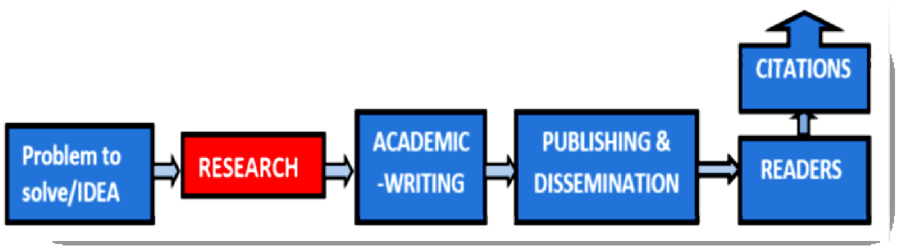


Figure 2: Focus of this-research.

In-order to-conduct a-survey and perform a document-analysis, the-study was divided into 3-distinctive-parts, which shown in-Figure 3.

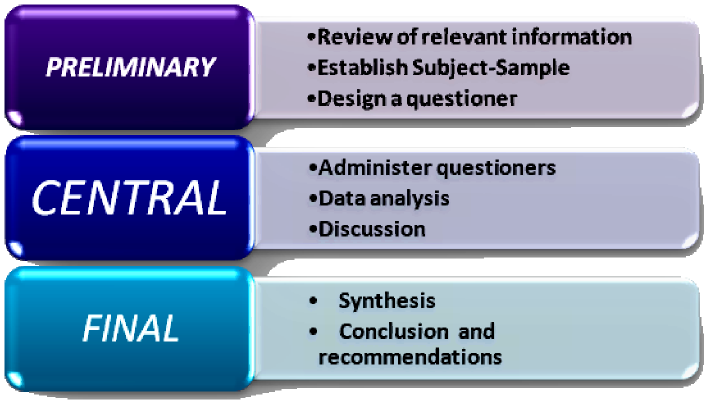


Figure 3: Sequential-parts of the-study (Starovoytova & Namango, 2016a).

2.2. Sample size and the rationale for its selection

To-evaluate perceptions on quality of the-scientific-research, among senior-faculty, at the-School of Engineering (SOE), Moi University (MU), confidential-self-report-questioner was designed and used, as the-main-instrument, for this-study, with the-sample-size of 15-subjects.

2.3. Main instruments used

The-study implemented an-approach of projective-technique, by requesting questionnaire-respondents questions, about their-perceptions of quality of scientific-research. The-respondents were guaranteed confidentiality, and the-questionnaire was filled in-anonymously, with no-identification-information. The designed-self-report-questionnaire was used in eliciting-information, from the-subject-sample; it consisted of two-sections, first-section is the-demographic-characteristics of the-subjects; and second section, on the-perception of engineering-faculty on research and its-quality. In-addition, interviews and observations were used, to-get more-information, relevant to the-subject-matter.

2.4. Data Analysis

The-questioner was pre-tested, to-ascertain its-validity and reliability. To-estimate reliability, the-correlation co-efficient was used (Kothari, 2004). The-Statistical-Package for Social-Sciences (SPPS-17, version 22)-computer software-program was applied, to-compute the Cronbach's alpha co-efficient. Descriptive- statistics was employed to-analyze both; qualitative and quantitative-data.

3. Results and analysis.

3.1. Validation of the instrument

Upon-validation, the-general-recommendation made, is that the-instrument was-acceptable, with some-minor-editing. Questionnaire-data was-coded, entered into-SPSS and checked for-errors. Data was-analyzed, list-wise, in SPSS, so that the-missing-values were-ignored. Cronbach's-alpha-test of internal consistency was performed, for perceptions and self-reports, and established high-inter item consistency (Cronbach's $a > 0.8$).

3.2. Analysis of the questioner.

Total of 15-questioners were administered (to senior-academic-faculty), out if which, 11 were submitted back, giving a-response-rate of 73 %.

3.2.1. Analysis of part1: Demographic-Characteristics
Figure 4 shows Demographic-Characteristics of the-respondents.

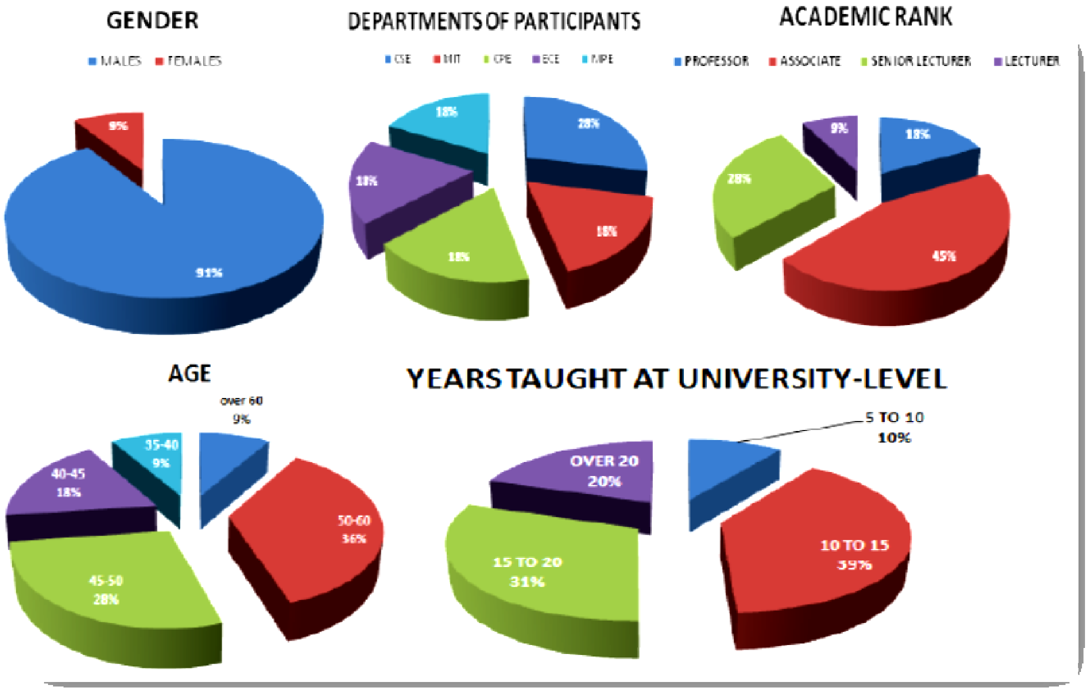


Figure 4: Demographics of the-respondents.

3.2.2. Responses to the questioner.

The-respondents identified *the-specific-part(s)* of the-research-process, that is-usually most-challenging for them, as-follows: (1) 73% indicated that getting sufficient and trustworthy-background-information is the- biggest-challenge (e.g. reviewing literature, especially so, for identifying reliable-sources, from-the Internet); (2) 64% pointed-out on Plan and Design of the-study, particularly on the-representative sample-size identification; (3) 55% indicated Analysis of Results; (4) 36 % stated that initial-Identification of an-idea/topic/problem for the-research; and (5) 9% indicated that both; Actual-research (experimentation, testing, recording of results), and Interpretation of Results are of their-concern.

The-respondents were also-asked to-identify the three-most important-ways to-increase the-*number* and the-*quality* of publications: 73% stated that the-Government should-provide more-funding, for-research, its-dissemination, and equipping the-laboratories. 64 % declared, that the-university should-offer additional monetary-reward, for each-publishing, at a-refereed-journal. 27% indicated that the-university should-cover the-entire-publishing-cost, while 9% identified that: (1) University should-provide a-list of reputable journals, for-academic-staff, to-publish-with; (2) University should-establish a-Plagiarism-Policy; (3) University should-publicize the-academic-staff, authoring the-highest-number of publications, in refereed journals (for-example annually); and (4) Senior-academic-staff, in-Schools and Departments, should-mentor and train junior-staff, on how to-publish joint or individual quality-research.

From the-interviews it-was-also-identified, that majority (82%) of the-sampled-engineering-faculty has some-misconceptions regarding the-*quality*-aspect of research; they perceived that quality-research just-equals ethical-research. Quality-research, however, is multifaceted, where ethical-considerations, although, important, are just its-small-fraction; to-understand-more on the-complex-concept of research quality, it-is-paramount, to-start-with the-overall-process/steps, involved in-a-research; followed by the-selected assessment-models of research-quality. Additional-myth, prevalent, among engineering-faculty, is that qualitative-research is inferior to quantitative-one, and hence it-is of *no* value to-engineers-researchers. The-authors will-attempt to-address and de-mystify the-issue, in-the-next-sections.

4. Discussion and Recommendations.

4.1. The-overall-process of Research

Many-authors, such-as, for-example: Moule & Goodman (2009); Hek *et al,* (2006); and Parahoo (2006), have-described the-research-process; each coming-up with a-different-number of stages, but, essentially, they-contain the-same-elements. The-precise-stages of the-research-process, and the-order, in-which they are undertaken, will-vary, depending on the-nature of the-research, but will-always-follow a-systematic pattern, from initialideas through to-dissemination and implementation. Although, the research-process will-be-presented as-a-linear, sequential-process, the-stages are-often revisited, several-times, during the process. Moreover, every-research-has its-unique-objectives, requirements, and time- frames, so this-is *only* a-general-template; besides, according to Gauch (2003), the-steps usually-represent the-overall-process (flexible-frame) and, hence, they should-be-viewed as an-ever-changing practice, rather than a-fixed-set, of unavoidable-steps. Figure 5 illustrates the-process, as it-will-be-described, in this-paper.

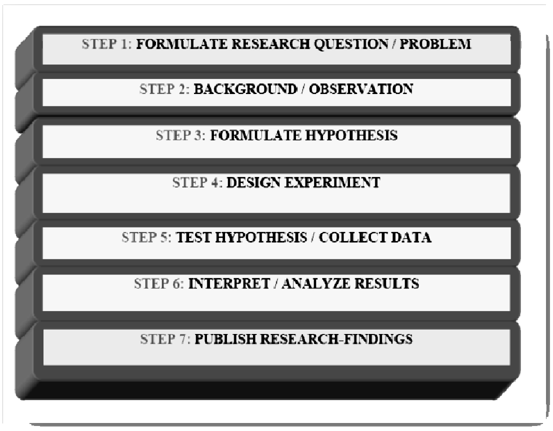


Figure 5: Conventional research-process

Step 1: Formulate Research question / Problem

This is the-most-important-step in-research; often-coming from some-limitations and imperfections of a-particular-subject-matter, leading to a-thought: "What we-currently-have, is-not-quite good-enough – we-can-do-better ..." The-idea for-research might-arise from an-actual-problem, faced by the-researcher, from professional-discussion among-colleagues, from an-issue in the-media, from reading an-article or a book, or from a 'call for proposals', among-others. The-research-question defines the 'area of interest', but it is not a-declarative-statement, like a-hypothesis. The-central-research-question may-be complemented, by several-secondary-questions, to-narrow the-focus. Moreover, research-question should be capable of being confirmed or disproved.

Step 2: Background / Observation

This-step, essentially, provides a-background-information, to-enable a-reader to-comprehend the-problem, at-hand (for-example: How has the-work been-done, previously? What similar-work has-been-leading-up, to this-point? Study state of the-art (literature-review, projects, informal-discussions, etc); what distinguishes previous-work from what the-researchers want to-do? Who / What will-be-impacted by this-research? and so-on).

Step 3: Formulate hypothesis

A-hypothesis is a-statement that can-be-tested, and is-used, mostly, in-experimental-research. A-scientific hypothesis states the 'predicted' (educated-guess) relationship, amongst-variables. The-hypothesis shall contain two-types of variables: *Independent-Variables* (the-ones, the-researcher controls; it-is what, the researcher, changes to-cause a-certain-effect), and *Dependent-Variables* (the-ones, the-researcher measures or observes). Hypothesis should-be-stated in declarative-form, and should-be brief, simple, specific and conceptually-clear (up-to-the-point). For-example, a-possible-hypothesis-format could-be: 'If ...... then .... (because ....) '.

It-serves to-bring clarity, specificity, and focus, to a-research-problem. This-step, however, is optional; as one can-conduct valid-research, without constructing any-hypothesis. On the-other-hand, one can construct as-many-hypothesis, as-appropriate. The-hypothesis should-be also: (1) capable of verification; (2) related to-the-existing-body of knowledge (and able to-add to the-existing-knowledge); and (3) expressed in-terms, that can-be-measured.

Qualitative-designs and surveys do-*not*, usually, have a-hypothesis, although, sometimes, surveys do-test for-differences, between-groups, and thus, might-use one. Statistics are required, to-test the- hypothesis, which has-to-be very-precisely-written. The-hypothesis expresses the-predicted-outcome, of the-experiment, either in-positive or negative-terms.

Step 4: Design experiment

This-step includes planning, in-detail, all-the-steps of the-experimental-phase, to-enable-others to-repeat-it. Moreover, some-researchers perceive this-section as paramount, as: 'If one fails to-plan, one planned to-fail!' The-plan for the-study is-referred-to, as the-instrumentation-plan, which-serves-as the-road-map, for the-entire-study, specifying who will-participate, in-the-study; how, when, and where, data will-be collected; and the-detailed-content of the-program.

Step 5: Test hypothesis / Collect data

This-step is accomplished, by-implementation of methods (e.g. prototyping), auxiliary-tools (e.g. simulation), field and/or laboratory-work, as-well-as, pilot-testing and refinement, can-be-performed. Moreover, Karl Popper's Basic Scientific Principle of *Falsifiability*, defined as the-inherent-testability of any-scientific-hypothesis (it can-be-proven false) can-be-considered. According to the-principle: even large-number of supporting-observations cannot prove a-hypothesis; and even a-single negative observation will-falsificate-it (Goodman´s paradox); and Need of intuition (there is no 'meta-theory', which tells how-to-invent the-hypothesis or how-to-find a-proof for-it *(Popper, 2005)).*

Step 6: Interpret / Analyze results

Data-analysis is most-demanding-phase, from an-intellectual-point of view. Contrary-to-many people's expectations, computer-software-analysis-packages, such-as NVivo (for qualitative-analysis) and SPSS (for quantitative-analysis) do *not*, actually, do the-analysis, they-simply provide-practical-tools, to-manage the-data, more-easily. The-researcher, still, has-to-manage and guide-the-process, and perform sound- interpretation of the-results. Statistical-methods of data-analysis are also-commonly-used.

Again, data-interpretation-methods vary, greatly, depending on the-theoretical-focus (i.e., Qualitative or Quantitative-research) and methods (e.g., Multiple-Regression, Grounded-Theory, etc.). For-example, *Descriptive statistical analysis* focuses on the-measurement of a-complete-population's characteristics (e.g., all-the-graduating-students of 2016), assesses each-member of that population on key-variables (gender, age, etc.), and computes summary-values (such as a-mean or standard-deviation), based on those-values. The-research-questions, for a-descriptive-study, are based on developing an understanding of the-population, as-a-whole. In-contrast to-descriptive-statistics, *inferential statistical analysis* involves using information, from-a-sample of a-population, to-make inferences, or estimates, about the-population. The-research-questions are based on-generalizing, from the-sample, to the-larger-population, in-some-key-ways.

Besides, data-is collected in-a-variety of ways, depending on the-research-question, the-study design, and the-nature, of the-sample. The-most-commonly-used-methods are: *questionnaires*, *interviews,* and *observations*.

Step 7: Publish findings

A-research-result is *not* a-contribution to the-field, if no-one knows about-it, or can-use-it. Publishing/ dissemination research-findings is, therefore, paramount in the-career of every-researcher. This-step will-be addressed, in-detail, in a-separate-paper (# 4 of this-tetralogy).

The-research-process described, is a-very-generalized-model of carrying-out research, mainly for social-sciences, pure-sciences and humanities. Science and Technology, on-the-other-hand, have different- objectives; Science aims at-new-information, while technology and engineering aim at-utility; hence, at-times, engineering apply specific-approaches, to-research, which are-outlined in-the-next-section.

4.2. Research in Engineering

The-traditional-outlook of the-relationship, between-science and technology/engineering, is-linear: Basic-science makes discoveries, which-are turned-into-inventions, by applied-science and, then, developed into-useful-artifacts, by technologists and engineers (Henry, 2002). According to Wieringa & Heerkens (2007); Yin (2003); and McKelvey (1985), among-others, however, this-view is *not*-accurate, in-general.

Ritchie *et al.* (2005), for-example, explains different-roles of engineers and scientists: 'unlike scientists, who proceed within the-framework of scientific-laws, engineers employ heuristic-laws, to-arrive at-design-solutions. Heuristics do-not-guarantee-solutions, but they-reduce the-search-time, in solving a-problem'. The-other-difference between engineering and science is that engineering-problems are-usually vague (Jonassen, 2003). Besides, a-few 'right'- solutions, for one-task, can-co-exist-together, depending on the-resources, required, for performing the-task.

Three-main-categories of scientific-research, about technology and engineering, are (Shavelson &Towne, 2002): (1) Research about the-nature of technical-artifacts (*ontology*) (involving ordinary engineering-sciences (statics, dynamics, theory of strength, circuit-theory, communication-theory, electricity, chemistry, etc; and Modeled, according to-theories of nature, i.e. physics); (2) Research of design and manufacturing (via variety of possible-approaches, according to psychology, sociology, linguistics, ergonomics, etc.); (3) Research of interactions in-use, utilization or adoption of technology; and (4) research of impacts of technology, where even-more multi-disciplinary-modes are-used (psychology, cultural-impacts, environmental-impacts, economical-effects, etc.)

Additionally, in studying the-creation of technology, 3 approaches can-be considered (Hong, 2005): (1) *Design-science-approach* on: Efficiency of methods and tools; Performance of design-teams; Managing the-design-process; managing-requirements, technologies, costs, manufacturability; and other-constraints; (2) *Industrial-management-approach* on: Technology-business-interactions; Strategy-issues, Networking- issues, Managing engineers, processes, quality; and Managing competence and knowledge; and (3) *Manufacturing-approach* on: Processes; Machinery; Logistics; Material and energy-flows; Design- manufacturing-interface; Agility, and Flexibility.

Most-types of engineering-research is, actually, design-science-research or design-based-research, the-end-result of which, are invention-devices, or systems (that did-not-exist before) or are-improvements, over existing-devices or systems, created by-human-effort (by bringing-together-technologies, to-meet human-needs or to-solve-problems).

Historically, Engineers are great-inventors; according to NAP (2005), cited by Starovoytova &Namango (2016 b): *Twenty Engineering Achievements that Transformed our Lives are:* Electrification, Automobile, Airplane, Water Supply and Distribution, Electronics, Radio and Television, Agricultural Mechanization, Computers, Telephone, Air Conditioning and Refrigeration, Highways, Spacecraft, Internet, Imaging, Household Appliances, Health Technologies, Petroleum and Petrochemical Technologies, Laser and Fiber Optics, Nuclear Technologies, and High-performance Materials.

Typically, the-engineer creates a-model, for some-technical-artifact; the-model (prototype or system-architecture) may-focus on some-functional-property, like: performance, quality, reliability, or usability. All-the-variables, that will-be-manipulated and measured, should-be identified; moreover the research-outcomes should-be-measurable. Only after creating a-prototype of the-design (from drawings), the-engineer might-discover, that something is not-precise (for-example, parts did-not-mate, properly). The-part would have to-be-redesigned, again, and, if needed, again, and again, until a-satisfactory-solution was-reached (Camarinha-Matos, 2016). This continuous-iterative-sequential-process is represented in the-Figure 6. Each-step in the-process is accomplished, in-order, or sequence; only after the-previous-steps have-been-completed, satisfactory. Common-engineering-methodology-approaches used, are: *A-cross sectional-design, Time-series, and Panel Designs.*

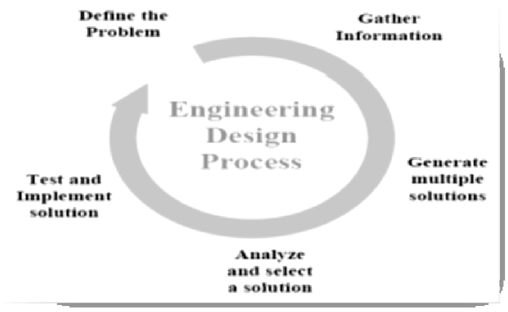


Figure 6: Engineering design-research-process (Khandani, 2005).

Several-approaches can-be-used for design-validation (to-check its construct, internal and external-validity), such-as: (1) *Laboratory or field-experiments*; (2) *Action-research*; (3) *Case-studies*; (4) *Pilot-projects* (Hall *et al,* 2006; Mammela, 2006); and (5) *Modeling* (explicit model-based-process metrics in latency, safety, quality, schedule, cost and sustainability). Generating a-suitable-mathematical-model, of a-problem, allows engineers to-analyze-it (sometimes definitively), and to-test potential-solutions. As a-rule, multiple-reasonable-solutions exist, so Engineers must-evaluate the-different-design-choices (commonly *via* decision-matrix), on their- merits and choose the-solution, which best meets their-requirements. Genrich Altshuller, a-brilliant Russian-engineer-inventor, after gathering statistics, on over 40,000 patents, suggested that compromises are at-the-heart of 'low-level' engineering-designs, while at a-higher-level, the-best-design is-one, which eliminates the-core-contradiction(s), causing-the-problem (for more-details refer-to Starovoytova *et. al.,* 2015).

On-the-other-hand, design-activity-occurs over-a-period of time, and requires a-step-by-step methodology. The-five-steps, used for solving design-problems are (Khandani, 2005): (1) Define the-problem (contains a-listing of the-product or customer-requirements and, specially, information about product-functions and features); (2) Gather pertinent-information (Relevant-information for the-design of the-product and its-functional specifications is obtained); (3) Generate multiple-solutions (Once the-details of the-design are clearly-identified, the-design-team with inputs from test, manufacturing, and marketing-teams generates multiple-alternatives, to-achieve the-goals and the-requirements of the-design); (4) Analyze and select a-best-solution (Considering cost, safety, and other-criteria for-selection, the- more-promising-alternative is selected, for further-analysis); and (5) Test and implement the-solution (A-survey regarding the-availability of similar-products in the-market, should-be-performed, at this-stage. Detail-design and analysis-step enables a-complete-study of the-solutions and result-in-identification of the-final-design that best-fits the-product-requirements. Following this-step, a-prototype of the-design is constructed and functional-tests are-performed, to-verify and, possibly, modify the-design.

Designing, building, and experimenting with physical or computational-simulation-models are central problem-solving-practices, in engineering. *Simulation* is another-important-tool, in engineering and research. It-can help, significantly, when the-performance of the-experiment, in-the-real world, would-take a-long-period of time (e.g. beyond the-duration of the-research-project). Different-Engineering Research methods are shown in Figure 7.

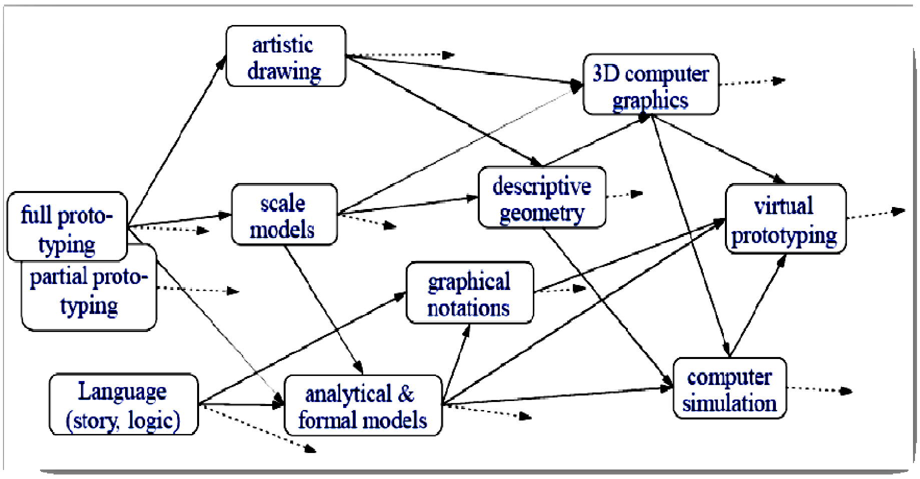


Figure 7: Engineering-Research-Methods (Hong, 2005).

More-detail about engineering-research and design is thoroughly-presented in the-literature, in particular Camarinha-Matos (2016); Clark & Creswell (2010); and Hong, (2005).

4.3. Qualitative-research vs. Quantitative-research

There are two-major-types of empirical-research-design: qualitative-research and quantitative-research. Qualitative-research is, often, more-difficult, for engineers, since they mainly-adapted quantitative-studies (Borrego, 2007); perceiving quantitative-approach as-much-more-superior and multi-faceted. Traditionally, Engineering-faculty heavily-depend on empirical-quantitative-research, via: relevant-theories, design, laboratory-experimentation, testing (using, at-times, sophisticated-equipment), reliable-computation, and statistical-analysis; leaving very-little-room to-express, openly, their-opinions, on the-subject-matter. Engineering-Scientific-writing, hence, is perceived, to-be more of a fixed, factual and 'dry'-reporting, than inquisitive-argumentative-writing. Recently, however, a whole-new-branch—Engineering Education Research—appeared, where both-methods; quantitative and qualitative, are-successfully-coexist, utilized (individually or, more-and-more, collaboratively), and valued (based on-their-own-specific-merit and potential-contribution, to-provide a-solid-foundation, in proving a-point or proposing solution(s)). Streveler & Smith (2006) cited guidelines in-Scientific-Research in Education, provided by the-National Research-Council (NRC), USA. According to the NRC, rigorous-scientific-research, in-engineering- education should: (1) Pose significant-questions that can-be-investigated, empirically; (2) Link research to-relevant-theory; (3) Use-methods that permit direct-investigation of the-question; (4) Provide a-coherent and explicit-chain of reasoning; (5) Replicate and generalize, across-studies; and (6) Disclose-research, to-encourage professional-scrutiny and critique (NRC, 2002).

Another-huge-misconception is that qualitative-study, is rather-primitive—just interview a-small number of people, out in the-street, and report the-findings—very-easy! Apparently, it is *not*, as it appears, at first-sight, especially for these, who never come-across or, even, considered conducting such a-research. As (Have, 2004) puts-forward, quantitative *versus* qualitative, is-not a-matter of rigorousness or quality, but *is* a-matter of research-focus and question. The-authors of this-paper, several-times, personally, experienced instances, where, for-example, the-board of examiners, assessing students'-research-proposals (involving qualitative-approach), categorically and with-supremacy, saying: 'NO, this is *not* Engineering, it-is for social-sciences and arts', clearly separating 'us'(engineers) and 'them'(the-rest of the-academia). The-goal in both-methods, however, is 'to produce theoretically structured descriptions of the empirical world that are both meaningful and useful' (Borrego, 2007), that in a-dialogue, between ideas and evidence, produced. Moreover, study by Koro-Ljungberg & Douglas, ague, that: qualitative-research can-be just-as-difficult, to-conceptualize, and be-as methodologically and theoretically-challenging, if not *more*-challenging, than quantitative-research (Koro-Ljungberg & Douglas, 2014). Lastly, for research to-be of high-quality, it needs to be problem-, as-well-as, method-led. Yet, as pointed-out by Gadamer (1993), the-rigorous-application of a-method, does-*not*-guarantee productive and high-quality-research, rather it-can-lead to 'method-sterility'. He-also-stated that for a-researcher to-be inventive, a-mastery of the-methods, used-in-research, is required; an unhealthy-overemphasis, on-either, can-direct to a-lack of quality.

In this-regard, to-transmit more-light, on the-subject-matter, the-following-section, will, hopefully, be of benefit, for these of us, never-practiced qualitative-research or, still, 'sitting on-the-fence'.

Quantitative involves collection of numerical-data, that need-to-be summarized, described, and statistically analyzed. Graphs, charts, cross-tabulations, descriptive-statistics, multiple-regressions, analyses of variance, and advanced-modeling-techniques may, eventually, be-used, to-build sophisticated- explanations of how the-data addresses the-original-question. Such-research-designs may, or may-not, have a hypothesis; they may-be-experimental and/or observational. *Qualitative,* on the-other-hand, use narrative, words, documents or graphical-material, as their-data-source, and analyze-material, by describing and summarizing the-mass of words, generated by interviews, or observational-data, to-identify themes, relationships, concepts and, in-some-cases, to-develop-theory, which can-be tested, using advanced- analytical-techniques.

In-any-qualitative or quantitative-research, the-researcher(s) might-collect primary or secondary data. *Primary-data* is data-collected, specifically for the-research, such as-through: interviews, questionnaires, and test-results. *Secondary-data* is data, which already exists, such-as: census-data, which can-be re-used, for the-research. It-is an-acceptable-research-practice to-use secondary-data, wherever possible (proper-attribution should-be-given to-sources). Broadly-speaking, a-researcher has three-choices: taking a-predominantly-quantitative-approach; taking a-predominantly-qualitative-approach; or taking an-approach that draws on both; quantitative and qualitative-methodologies. Mixed method-research, where research includes qualitative and quantitative-elements, using both; primary and secondary-data, is also becoming more-common (Kara, 2012).

Within-quantitative and qualitative-research-methodologies there are a-number of well-established study-designs.

Qualitative-research is linked with the-philosophical and theoretical-stance of social constructionizm. Qualitative-research-designs are: (1) *Action Research* is used to-investigate the-effects of small-scale-interventions, in real-life-situations. Although included within qualitative research-designs, the-researcher often-collects a-combination of qualitative and quantitative-data; (2) *Ethnography* is a-form of qualitative-research, used to-investigate cultures and population-sub-groups and seeks to-explore, describe and explain cultural-behavior; (3) *Phenomenology*-- literally-means the-study of a-phenomena. It-is a-way of describing things that are part of the-real-world, such-as: events, situations, experiences or concepts. Phenomenological-research investigates individuals' lived-experiences; and (4) *Grounded theory* is a-form of research that goes-beyond collecting and analyzing-data, to-add to the-existing-body of knowledge. In-grounded-theory the-emphasis is on-developing new-knowledge and new-theories, about the-topic being-investigated.

The-following-steps are-typical for qualitative-data-analysis: Familiarization with the-data, through repeated-reading, listening, etc.; Transcription of interview-material; Organization and indexing of data, for easy-retrieval and identification (e.g. by-hand or computerized-programs, such-as NUD*IST, Nvivo); Identification of sensitive-data; Coding; Identification of themes; Development of provisional categories; Exploration of relationships between-categories; Refinement of themes and categories; and Development of theory and incorporation of pre-existing-knowledge.

Quantitative research, on-the-other-hand, is linked with the-philosophical and theoretical-stance of positivism. Measurement is at-the-heart of quantitative-research-approaches. Quantitative-research-designs are: (1) *Intervention-studies*-used to-evaluate the-effectiveness of an-intervention. The-classic intervention study is the-randomized-controlled-trial, where two-treatments are compared, against-each-other. The-process of randomization removes self-selection-bias in an-attempt to 'isolate' the-treatment-effect; (2) *Cross-sectional studies*-used to-survey, where data are-collected from, a-number of individuals about: their-health, opinions, beliefs, attitudes or behaviors, with-regard to a-given-topic (postal-questionnaires, face-to-face-interviews, or telephone-interviews, can-be used, as research-tools); (3) *Cohort studies*-in contrast-with a-cross-sectional-study, which provides a-snap-shot, a cohort-study is longitudinal. Cohort studies tend to-require large-samples and require long-follow-up-periods. Consequently, they-are expensive to-undertake; (4) *Case-control studies*-is, in-many-ways, the-reverse of a-cohort-study. They-are usually retrospective; and although-considered methodologically-inferior, to-cohort-studies, case-control- studies have a-number of advantages, in-terms of time and cost, and they-are an-efficient-way of studying associations.

Although methods-used can-vary, greatly, the-following-steps are-common in quantitative-data analysis: (1) Identifying a-data-entry and analysis-manager (e.g., SPSS http://www.spss.com); (2) Reviewing-data (e.g., surveys, questionnaires, etc.) for completeness; (3) Coding-data; (4) Conducting Data-Entry; and (5) Analyzing-Data (e.g., sample-descriptive and/or other-statistical-tests).

4.4. Possible-shift in dominance of research.

The-global-research-landscape is changing, being described as 'the-new-geography of Science'; Western dominance seems to-be-prominent, in-research, however, some-scholars, such-as Simon Marginson, argue that the-East-Asian *Confucian-model* could-take-over the-Western-model. This could-be due-to changes in-funding for research, both; in the-East and the-West. Focused on emphasizing educational-achievement, East-Asian-cultures, mainly China and South-Korea, have-encouraged the-increase of funding, for research-expansion (Marginson, 2011). In-contrast, in-UK and in-some-states of the-USA, funding-cuts for university-research is observed, which may-lead to-the-future-decline, of Western-dominance, in-research. For-example, between 2008 and 2009, business R&D investment in the U.S. declined from USD 259 to USD 247 billion (SEI, 2012).

Moreover, between 2002 and 2010, state-funding for the-Nation's-top 101 public-research-universities, decreased by 10%, after adjusting for-inflation (SEI, 2012). Furthermore, more-than 50% of U.S.A. scholars, with doctorates, in-engineering and nearly 30%, with master's degrees, in-engineering, in 2002, were-foreign-nationals (NSB, 2003). Comparisons with-other-countries reveal alarming-differences. In-China and Japan, more than two-thirds of bachelor's degrees are awarded in-science and engineering. In-the 25 member-countries of the-European-Union, 36 % of bachelor's degrees are in-science and engineering, compared to only 24% in the U.S.A., even though a-comparable number of degrees is awarded. The-gap is even-larger, for science and engineering PhDs (OECD, 2003). This-echoes the-findings of other-assessments by the: Council on Competitiveness (2004); President's Council of Advisors on Science and Technology (PCAST, 2004a; b); National-Science-Board (2003); National-Academies (COSEPUP, 2002; NAE, 2005); and other distinguished-bodies, such-as: DOE, (2003); and NCMST (2000).

4.5. Priority in-research, in-developing-countries

The-value and impact of an-engineering-research is based on its-applicability. In-developed-countries, research is based, ideally, on real-economic-problems, and, thus, helps in providing-solutions, to-their economic problems, enhancing their-competitiveness. In-Europe, America, Australia, Japan, Korea and China, among-others, a-lot of funding is provided to-research, based on Economic-problems, innovation and applied-research. In-UK, for-example, Economic and Social-Research-Council (ESRC) is the UK's largest-organization, for funding-research, on economic and social-issues (Economic & Social Research Council).

In-developing-countries, like Kenya, due to-scarcity of resources, there is a-need to-allocate-them, based on the-priority and the-potential-impact. Four-levels can-be-considered, for decision-making (see Figure 8), as proposed by Shukla (2016); where the-highest-priority & highest-impact is allocated for Applied and Problem-based-research.

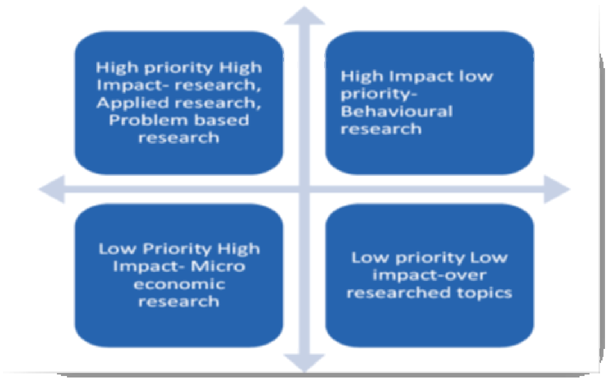


Figure 8: Matrix of Prioritization in Research (Shukla, 2016).

In-the-view of possible-shift, in-global-dominance of research, developing-countries, including Kenya, should establish their-own-niche, concentrating more on *real*-economic-problems, they currently face. Most-African-countries need to-build-up the-research-capacity, particularly the-necessary human capital; and to-assertively-develop a-clear-focus, on-the-research-questions of relevance, and potential- utilization, for the-benefit of society, in-contemporary-circumstances. This, in-turn, will-help to-insure the- sustainability of knowledge-generation, as-well-as, the-increased-likelihood of relevance, and applicability of research, solving African-problems, by Africans, for Africans.

On-the-other-hand, interest-in and demand-for the-evaluation of research-quality are increasing, internationally. Several-factors account for-this: agendas for-accountability and good-governance and management; and fiscal-austerity, in-many-countries. Guthrie *et al.* (2013) also-pointed-out, that 'a-shift in the type of evaluation needed: from the traditional, summative, assessment to more formative evaluations and those covering wider-outputs, from research'. For the-benefit to the-potential-readers, the-issue of research-quality-assessment is illuminated, further.

4.6. Models of assessment of research-quality

Here, *quality* is defined as a-standard of excellence, measured against other-things of a-similar-kind. Characteristics of *a-high-quality* research-study include (McMillan, 2008): (1) A-well - defined research topic and a-clear-hypothesis; (2) Focused-research-questions, responsive, to a-literature-review; (3) An-absence of research-bias; (4) High-quality-data fit for their-intended-use (reliable, valid, relevant, and accurate); (5) Analytical-methods, appropriate to-the-data and the-questions (descriptive or inferential); (6) Findings of the-study, written in-a-way, which brings clarity, to important-issues; (7) Tables and graphics, which are-clear, accurate and understandable, with appropriate-labeling of data-values, cut-points and thresholds; (8) Include both; statistical-significance-results and effect-sizes, when possible; and (9) The conclusions and recommendations both; logical and consistent, with the-findings.

On the-other-hand, *rigor* refers to the-strength of the-research-design, in-terms of ensuring that all-procedures have-been-followed meticulously, that all-possible perplexing-factors have-been-eliminated, and that the-user can-be-confident, that the-conclusions are trustworthy. The-quality of research is accessed via two-concepts: validity and reliability. *Validity* is the-extent, to-which the-research-measures are with *no* bias or distortion, while *reliability* refers to the-consistency of measurement, within a-study. Some qualitative-researchers reject the-terms 'validity' and 'reliability' because of their-association with the- quantitative-research-tradition, and the-assumption, embedded in-their-definition, that research can-be entirely-objective and free-from-bias (Holloway & Wheeler, 2002). Such-researchers may-prefer to-use concepts such-as credibility, trustworthiness and transparency, to-describe the-quality of the-research, but the-underlying-concept of rigor, and the-use of a-systematic-approach, remains, largely, the-same.

Research-evaluation is exercised for compound-rationales: (1) to-provide accountability; (2) for analysis and learning; (3) to-facilitate funding-allocation; and (4) for advocacy. There is a-rising-need to-demonstrate, clearly, the-impact of research, and to-provide-substantiation, that publicly-funded-research presents a-good-return, on-investment, for the-research-funders and, eventually, the-tax-payer (Boehkolt, 2002; Fahrenkrog *et al.,* 2002).

On-the-other-hand, there-is *no* universal-'golden-standard' or guidelines, which can-be-used, to-evaluate the-quality of research, across-the-board. To-illustrate-this, the-following-list shows many frameworks, established, for research-quality-evaluation, in-different-parts of the-world. *Selected-list* is as follows: Research Excellence Framework (REF), *UK*; STAR METRICS, *USA*; The Excellence in Research for *Australia* (ERA); Canadian Academy of Health-Science (CAHS) Payback-Framework, *Canada*; National Institute of Health Research (NIHR) Dashboard, *UK*; Productive-Interactions: A-framework, developed across-several-countries in *Europe,* for multiple-disciplines; Evaluation-Agency for Research and Higher-Education (AERES), *France*; Congressionally-Directed Medical-Research-Program (CDMRP), *USA*; National-Commission for University-Evaluation and Accreditation (CONEAU), *Argentina*; National Institute for Academic-Degrees and University-Evaluation (NIAD-UE), *Japan*; Knowledge-Management and Evaluation-Directorate of the National-Research-Fund (NRF KM&E), *South-Africa*; Performance Based-Research-Fund (PBRF), *New Zealand*; Spanish-State-Program for University-Quality-Assurance (PNECU), *Spain*; and Standard-Evaluation-Protocol (SEP), *Netherlands*. For-more-details (Brief description; Origin and rationale; Scope; Measurement; Application-to-date; Analysis; Wider applicability; and SWOT-analysis) on *each*-of-the-frameworks, listed-above, refer to Guthrie *et al.* (2013).

Additionally, Leary (1985) pointed-out on *research-quality-indexes*, that might-help to-identify quality-research; for-example: **(1)** *Scholarship* is defined as publish-ability, productivity, complexity of thought, distinction of endeavor, and progress of the-enterprise. Dillon, in 1982, has projected a-hypothesis that scholarship is reflected in-the-occurrence of *colons*, in-the-title of a-research-paper. The-argument is that colons are needed, to-adequately-express the-complexity of the-more-scholarly-efforts, leading to the-term' titular-colonicity'. Later-on, Perry tested the-hypothesis, by analyzing 21,000 scientific-papers from 7classes of journals, and confirmed it (Perry, 1985); and **(2)** *Citation frequency:* Citations-are, basically a *post-factum* peer-review, in-a-quantitative-manner; the-other-writers, vote, through their- own-writings, by citing those-works, they-consider relevant or important, to-their-own (Tijssen, 2002). Rather-than comparing, average or median-citation-scores, the-high-end, of the-citation-distribution, in-the *various disciplines,* should-be-considered, as a-benchmark, *in the-same field* (Tijssen, 2002).

The-number of citations and such-derivatives as *Hirsch index* (*h*-index) are produced, by a-number of organizations, including the-inventors, currently Thomson Reuters (Thomson Reuters, 2016); Web of Science; Scopus and Google. Usually the high-frequency of citation logically-presumes high- quality-paper. This however, is *not* always, the-case; a-phenomena-known as *Mathew-effect*, states:' the accuring of greater-increments of recognition, for a-particular-scientific-contributions, to a-scientists of considerable-repute, and withholding of such-recognition, from scienticts, who have-not, yet, made their mark'(Merton, 1973). This-effect can-be illustrated, for-example, by a-study of the-top-five-journals, in-economics (Frey *et al.,* 2009) shows that of the-275-articles, published in 2007, 43% originated from scientists, working at only a few-top-American-universities (Harvard, Yale, Princeton, MIT, Chicago, Berkeley, and Stanford). The-professors of these-universities are, basically, accepted *by- default of-affiliation*; the-other-authors must-then go-through a-tough-competition, for the-few remaining-publication-slots. A-famous-verse, from the-book 'Animal-Farm', by George Orwell, can be paraphrased: All-*authors* are equal, but some are more-equal, than others.

Moreover, it-is perceived, that the-higher the-*h*–index, the-more-established a-researcher would be. However, the-principles of variability of impact-factor must-always be-borne in-mind, as indicated in-the '*bibliometrics ten commandments'* outlined by Thomson-Reuters (Pendlebury, 2008) that includes '*compare* *likes and likes*'- the 'golden rule' of citation-analysis. Different-fields of research exhibit quite different citation-rates or averages, and the-difference can-be as-much-as 10:1. For-example, the-average 10-year-old-paper, in molecular-biology and genetics, may-collect 40 citations, whereas the-average 10-year-old-paper in a-computer-science-journal may-garner a-relatively-modest 4 citations, over-time or citation 'window' (Pendlebury, 2008); and **(3)** *Alleged-maturity of disciplines/methods:* There-is-also a-widespread-misconception that, researchers, in the-more 'mature'-disciplines (for-example, physics) or engineering, do higher-quality-research, than those in social-sciences or humanities. The-rationalization, behind the-perception, is that the-concepts of the-disciplines are quantified and almost-always-expressed, as-mathematical-equations. The-mathematical-equations, themselves, vary, from the-simplest-algebraic, to differential, intergo-differential, and up-to the-most-complex--integral-equations. Even-within the-same discipline, one-can-use methods, of different-complexity; perception, however, the-higher-the-complexity of a-tool, used, the-higher-the research-quality.

Numerous-tools, are-currently-available, to-assess the-quality of a-research, such-as (Brutscher *et al.,* 2008; Grant *et al.,* 2009): (1) An-entirely-new-science recently-evolved, *Scientometrics* or *Bibliometrics*, deals with, nothing-else, but measuring and comparing, the-publication-output, of scientists. This-science has, by now, obtained its-own-professors and its-own-journals, and consequently the-measurements are also-becoming more-complex and less-transparent, which then, in-turn, justifies even-more bibliometric- research (McMillan, 2008). Moreover, several-public-agencies (e.g. Centre d'Etudes de la science et de la Technology, in Switzerland) and university-institutions (e.g. Centre for Science and Technology-Studies, University of Leiden, the-Netherlands), deal, exclusively, with the-measurement of research-inputs and outputs, on the-basis of bibliometric and scientometric-research; (2) Peer-review; (3) Review of available-frameworks (4) Data-mining; (5) Logic-models; (6) Data-visualization: (7) Economic-analysis; (8) Interviews; (9) Case-studies; (10) Site-visits; (11) Surveys; and (12) Document-review, among-others. Interested-readers can refer to Guthrie *et al.* (2013), for more-details on *each* of the-listed-above-tools; where the-majority of the-tools are described, using the-following-reporting-template: Introduction; When should (the tool) be used? How is (the tool) used? Example-case-studies; and Summary.

According to Guthrie *et al.* (2013), research-evaluation-tools typically-fall-into one-of-two-groups, which-serve different-needs; multiple-methods are-required, if researchers' needs span both-groups. The-two-groups-are: (1) *formative tools* that are flexible and able to-deal with cross-disciplinary and multi disciplinary-assessment; and (2) *summative tools* that do-*not* require judgment or interpretation, and are quantitative, scalable, transparent, comparable and suitable, for high-frequency, longitudinal-use.

There is also *no*-agreement on the-meaning of 'research-excellence' and if, and how, it differs from research-quality. Some-academics think of research-impacts as part of research-quality (Ware, 2011; Boaz, 2003), while others perceive quality and impact as two-different-elements, constituting research-excellence (Grant *et al.,* 2010).

Furthermore, the-rating of quality, itself, is-also differ-widely. For-instance, HEFCE, UK uses star-classification or rating of research-quality, as-follows: (1) *four star*: 'outstanding-impacts, in-terms of their-reach and significance'; (2) *three star*: 'very-considerable-impacts, in-terms of their-reach and significance'; (3) *two star*: 'considerable-impacts, in-terms of their-reach and significance'; (4) *one star*: 'recognized, but modest-impacts, in-terms of their-reach and significance'; and (5) *unclassified*: 'the impact is, of little, or *no*-reach and significance; or the-impact was-*not* eligible; or the-impact was-*not*-underpinned, by excellent-research, produced by the-submitted-unit'(HEFCE *et al.,* 2011).

Besides, in-general, the-Journal Impact Factor (JIF), Author Impact Factor (AIF), and Web Impact Factor (WIF) also-contribute, significantly, towards measuring research-quality and visibility, if, however, *applied with caution* (Kumar & Fortunato, 2014; Bar-Ilan, 2008; Noruzi, 2006; Amin & Mabe, 2000). Moreover, *Altmetrics* provide additional-quantitative-research visibility/output and web-based impact-measurement indicators/tools, thus making research-impact-analysis and visibility-analysis more-complex, but-also rewarding (see Onyancha, 2015; Galigan & Dyas-Correia, 2013; Haustein *et al,* 2013; Piwowar, 2013; Thelwall & Kousha, 2013; McFedries, 2012).

Any-unbiased-consideration of metrics, as-well-as, of other-systems, for assessment of research-impact (Eisen *et al.,* 2013; Lee *et al.,* 2013) leads to-conclusions that 'qualitative-judgment' should-be a-preferred-option (Metric Tide, 2016; Hicks *et al.,* 2015; DORA, 2013). In-this-regard, selected-Quality-Criteria for Education-Research are-proposed in: Engineering-Education-Research (Borrego & Bernhard, 2011); Chemistry-Education-Research (Eybe & Schmidt, 2001); Qualitative Education-Research (Tracy, 2010); and Mathematics-Education-Research (Niss, 2010). Based on the-listed criteria, Bernhard & Baillie arrived at Tentative-Quality-criteria for (qualitative) Engineering-education- research, involving 3-parameters: (1) Quality of a-study, in-general; (2) Quality of the-results; and (3) Validity of the-results. Details on-all-above-mentioned-criteria can-be-accessed *via* Bernhard & Baillie (2016), where arguments, comparisons, and examples, are-provided, for-each.

The-next-section highlights major-findings of the-survey, and interviews, which, in-turn, necessitated further-elaborations.

4.7. Areas identified from-the-responses to-the-questionnaire.

4.7.1. Reviewing the literature/Document-Analysis

73%, of the-respondents, indicated that getting sufficient and trustworthy background-information is the-biggest-challenge (e.g. reviewing-literature, especially so, for identifying reliable-sources from the-Internet). The-following-sections will therefore, elaborate-more on the-issues of: (1) Reviewing the literature/Document-Analysis, and (2) Evaluation and selection the-most-appropriate and reliable-sources, particularly, from the-Internet.

Literature-Review gives theoretical-rationale of a-problem, being-studied, in a-particular-research- project; it situates the-research, within a-theoretical and disciplinary-context; Provides up-to date-position of research, in the-field; Relationships between-concepts; and Gaps in one's-understanding. It-also leads to-identification of appropriate-research-design; to refined-set of research-questions and/or hypotheses; and to the-contribution this-study will-make.

In-essence, it involve critically-reading, evaluating and organizing existing-literature, on the-topic, to-assess the-state of knowledge or the-state-of the-art, in the-area. It-is generally-done-alongside the-development of the-theoretical and conceptual-frameworks; and selecting among: cross-sectional, experimental or longitudinal-design, of the-study. Certain-themes should-start to-emerge, from the-literature, and the-gaps in the-literature should-soon-appear, necessitating even more-literature-review. Moreover, reading-widely enable solid and comprehensive-exposure, facilitating the-writer to-become an 'expert' in the-field of research.

Carrying-out a-literature-search is not a-trivial-task; it-is-helpful to-divide the-literature into sub topics, for ease of reading. Besides, authors should-avoid the-urge to-track-down every-possible-reference, related-to writer's subject-area. The-beginning of the-literature-review should-cite the-most-important historical-contributions, that build the-foundation to-the-topic, the-paper will-extend (Russel & Morrison, 2003). The-goal is *not* to-cite-everything, as in a-review-article, but to-cite the-most-influential- contributions, which directly-lead to-the-problem, the-article addresses.

Index-databases are used to-locate periodicals and reports, while catalogs--to-locate books and other-sources. Books may-be a-good-starting-point, but quickly become-out of date, if the-subject-matter is topical. In-addition to-books and text-books, there are also many-other-types of documents, available, such- as: Encyclopedias, Monographs, Different-types of papers, Reposts, and Conference workshop/symposia presentations, among-others.

The-writer also-would-come-across a-range of papers that fall into one, or more, of the-following-categories (Mammela, 2006): (1) *Papers reporting original research* (these take the-classic-format of introduction/background, methods, results, discussion); (2) *Reviews* of others work (these may be in-the-form of a highly-systematic-review to a-more-discursive-analysis of others' work); (3) *Opinion pieces* (most-journals have editorials, where the-writer is generally 'making a case' by drawing on research and other-evidence); (4) *Methodological papers* (where particular-research-methods or research instruments are discussed, often by presenting-data, to-illustrate particular-points); and (5) *Policy documents* (an-understanding of the-direction of relevant-policy and the-associated-policy-debates will assist in presenting a-wider-perspective).

Figure 9 shows the-arrangement of selected-documents, based on the-information-reliability and novelty.

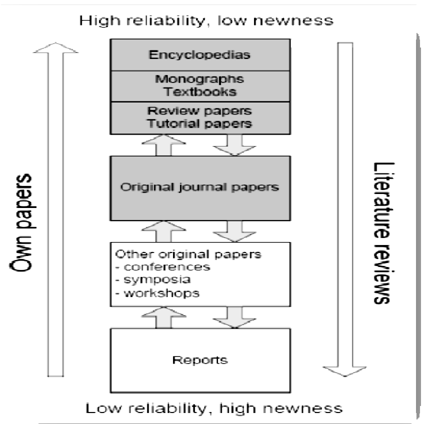


Figure 9: Reliability and newness, of selected-documents, for literature-review (Mammela, 2006).

At-particular-point, there will be too-much-information; hence collected-data should-be-refined. Beyond published-inprint-sources, evidence may be-found on the-internet, and various-online-resources, as-well-as, locating the-evidence, it must-be appraised and evaluated. The-authors should-challenge information and be a-little-skeptical of dramatic-information or information that conflicts, with commonly-accepted-ideas. The-new-information may-be-factual; to-prove that, however, one should-require a-robust-amount of evidence, from highly-credible-sources.

4.7. 2. Evaluation and selection the-most-appropriate and reliable-sources

Engineering is an-ever-changing, massive and still-expanding-subject. According to Starovoytova & Namango (2016b), currently, there-are-over 200 branches of engineering. The-engineering-scientific-arena is overstuffed with enormous-literature, available, in-the-form of books, journals, and the-information, from the-Internet. They say: 'Information is power!' the-author, however, would-like-to-clarify that only *reliable*-information is power. To-this-end, the-following-synopsis will-assist the-readers, to-select truly- attention-grabbing, interesting, and reliable-research, in the-huge-mass of insignificant-publications, and/or information of questionable-trustworthiness.

Document-reviews typically-involve 2 steps: (1) analyzing the-existing-evidence-base, which includes discovering what literature exists, and assessing the-content and suitability of the-literature, and identifying the-gaps; and (2) developing an-interpretation, so the-emergent-meanings can-be-articulated, their-relevance clarified, and the-findings refined, enhanced and strengthened. Through this-synthesis- process such-reviews can-add to-the-existing-pool of knowledge, even-though *no*-new primary-data are-collected (Guthrie *et al.,* 2013).

Characteristics of High-Quality Literature-Reviews: (1) Use of the-most-credible-sources, such-as professional-journals; (2) A-synthesis of relevant-papers, including those that may-be-contrary to one's hypotheses; (3) Intuitively-organized-overview, of the-literature, and a-conclusion, that summarizes and synthesizes key-ideas, from the-review (Trounson, 2011).

The-guidelines for research-conduct, of the-Carnegie-Mellon-University and the-Tufts University, stipulate that to-appraise and evaluate, the-source at-hand, throughout the-review of literature, 2-phases are-required: (1) the-initial-appraisal; and (2) the-critical-analysis of the-content.

The initial-appraisal should-be curried-out via vigilant-cross-checking of-the-following: (1) *Author* (the-author's credentials--institutional affiliation, identified (where he/she/they work(s)), educational- background, past-writings, or experience, and the-number of citations. A-book or an-article, written on a-topic in the-author's area of expertise, is-logically-considered more-valuable); (2) *Date of Publication* (This-date (year and month), is often-located on the-title-page, below the-name of the-publisher or the-year is indicated in the-copyright-date. On Web-pages, the-date of the-last-revision is usually at-the-bottom of the-home-page, sometimes every-page. The-researcher have to-decide, if the-source current, or out-of-date. Topic-areas, of continuing and rapid-development (for-example, sciences and engineering), do demand more-current-information. On-the-other-hand, topics in the-humanities often-require material, that was-written many-years, or even, several-decades, ago. At the-other-extreme, some-news-sources, on the-Web, nowadays, note the-hour and minute, that articles are-posted on their-site); It-is-imperative to-verify the-author, publisher, and the-date of publication; (3) *Edition or Revision* **(**a-first-edition, or subsequent (further-editions indicate a-source has-been revised and updated, to-reflect-changes in knowledge, include omissions, and harmonize with its-intended reader's needs). Also, many-printings or editions may-indicate that the-work has-become a-standard-source, in the-area, and is reliable); (4) *Publisher* (a-university-press, likely to-be-scholarly; Although the-fact that the-publisher is reputable does-*not* necessarily-guarantee quality, it-does-show that the-publisher may-have high-regard for the-source, being-published); and (5) *Title of Journal* (a-scholarly-peer-reviewed or a-popular journal, indicates different-levels of complexity in conveying-ideas. For-assistance, in-determining the-type of journal, see the latest-edition of *Katz's Magazines for Libraries*).

Critical Analysis of the substance: Having made an-initial-appraisal, the-writer, then should examine the-body of the-source. For-example, for a-book, the-preface should-be read, to-determine the-author's intentions for the-book, alongside with the-table of contents and the-index, to-get a-broad overview of the-material, it-covers. Assessment on whether bibliographies are included, should-be done. Then, the-author should read the-chapters, that specifically-address the-topic, of interest. Reading the-article abstract and scanning the-table of contents of a-journal or magazine-issue is also-useful. As with books, the-presence and quality of a-bibliography (at the-end of the-article) may-reflect the-overall-quality of the-document (*via* cross-checking accurateness, meticulous-care and effort, with which the-authors have prepared their-work).

In-particular, the-emphasis should be-put on (Trounson, 2011): (1) *Intended Audience* (the-type of audience the-author addressing: a-specialized or a-general audience; would, most-likely, shape the-content to-be either too-elementary, too-technical, too-advanced, or just-exact for the-researcher' needs); (2) *Objective Reasoning* **(**Is the-information covered fact, opinion, or propaganda? Facts can usually-be-verified; opinions, though, may-be-based on-factual-information, evolve from the-interpretation of facts. Skilled writers, however, can-make the-reader think that their-interpretations are facts); To-judge if the-information valid and well-researched, or it-is questionable and unsupported, by-evidence. Besides, the-assumptions should-be-reasonable, and errors or omissions should-be-noted; The-more-radically an-author departs from the-views of others, in-the-same-field, the-more-carefully and critically the-writer should-scrutinize their-ideas; The-author's point of view, should-be-objective and impartial, while the-language free of emotion-arousing-words, and bias); (3) *Coverage* (ranges from extensive or marginal; the-author needs to-update other-sources, substantiate other-materials read, or add new-information. The-writer should explore enough-sources, to-obtain a-variety of viewpoints. Besides, the-assessment should-be-made on-whether the-material primary or secondary, in-nature; Primary-sources are the-raw-material of the-research-process, while secondary-sources are-based on primary-sources. Books, encyclopedia-articles, and scholarly-journal-articles are considered as secondary-sources. In the-sciences and engineering, journal-articles and conference-proceedings, written by experimenters, reporting the-results of their-research are primary-documents. Both; primary and secondary-sources (when possible) should-be-used, to-provide broad-coverage; (4) *Writing Style* (logical-organization of publication, clearly-presented main-points, well-edited, systematic, and easy to-read, and the-author's argument); and (5) *Evaluative Reviews* (Locate critical-reviews of books, in a-reviewing-source, such as: Summon's Advanced- Search, Book-Review Index, Book-Review-Digest, and ProQuest Research-Library, among-others, to find-out if the-review positive, is the-book considered a-valuable-contribution, to-the-field; Does the-reviewer mention other-books that might be-better? If so, these-sources, should-be located, for more-information, on the-topic. In-case of multiple-reviewers, is-there any-controversy, among-the-critics? For Web-sites, however, consider consulting one of the Evaluation and reviewing-sources, on the-Internet, such-as the-CARS checklist and EasyBib's Website-Evaluation-tool (for Credibility, Accuracy, Reasonableness, and Support); and (6) *The-length of the-source* (Sources of detailed-information tend to-be-lengthy, while summary information can-be presented in a-few-pages or, even, a-paragraph).

On the-other-hand, many of us can-design and produce a-website; moreover anyone can-post information to-the-web, hence a-writer should-take-responsibility for evaluating the-validity and utility of the-information, by carefully assessing the-authority, of the-sources, and the-quality, of the-information, obtained.

Websites should-be-evaluated, based on: the-clearly-stated-purpose of the-site; last-update (should-be every 3-6 months); the-intended-audience; current and operational-links provided, to-more information. Besides, in identification of the-website's domain, *suffix* meanings are: *.org* (an-advocacy web-site, such as a-not-for-profit organization); *.com* (a-business or commercial-site); *.net* (a-site from a-network-organization or an-Internet-service-provider); *.edu* (a-site affiliated-with a-higher education-institution); *.gov* (a-government-site); and .~ (the-tilde; usually-indicates a-personal-page). The-domains *.gov, .edu* and *.ac* can *only* be-registered by-government and educational-institutions. For this-reason, they-reflect a-higher-order of authority than *.com, .org* or *.net* sites. Examples of sources that are, often, the-most-credible are: Official-government-websites; Institutional-sites, that represent universities, regulatory-agencies, governing-bodies, and respected-organizations, with specific-expertise (e.g., UNESCO; WHO, etc.); and Peer-reviewed-journals. Examples of sources that are, often, considered less-credible: Blogs; Web-forums; Individual or business-websites; and Materials, published by an-entity that may-have an-ulterior-motive (Duderstadt, 2009).

According-to CLRC Writing-Center, for any-information, provided on the *Internet,* the-points of concern are: (1) *Credibility* (to-ascertain the-information and author authenticity and reliability): the publishing or sponsoring organization; the author's credentials and authority/expertise on the-subject; the author/producer's contact information); (2) *Accuracy* (to-confirm that the-information is up-to-date, factual, detailed, and comprehensive): the-date of publication or copyright; Agreement or conflict with other sources; internal-contradictions, and relevancy to one's research-needs); (3) *Reasonableness* (to-examine that the-information is fair, objective, moderate, and consistent): bias expressed by the-author, host, or sponsor; and the-balance and neutrality of information; (4) *Support* (to-evaluate that the-information is reliable, accurate, reasonable, and well-supported): Citations referencing other well-cited works; Number of citation, and easy-retrieval; (5) *Design & style* (page-layout visual-appeal; the-images, enhancing the- message; the-language readable, and understandable; correct-grammar and spelling use).

Moreover, the-researher should-evaluate if the-document provides any of the-following: Basic-facts and information; Example or case-study; Argument or viewpoint (including those that contest hypothesis); Methodology or protocol; Historical-artifact; Raw-data; and Visual-source (image, chart, audio-visual). Besides, any-relevant-illustrations, diagrams, charts, tables, or other-supplemental-information, with their *attributed*-sources, are a-bonus.

To-sum-up, writers should-appreciate that *not* all-sources are-equal**.** Trustworthy-published sources should-be selected; e.g. e-books, University-Presses-publications, peer-reviewed-articles, or publications, by reputable-organizations, among-others. Wikipedia is always a-good-start, as it usually gives a-rather-balanced-overview; however, it is much-more-beneficial to-read the-original-sources (cited in Wikipedia), to-make one' own-overview.

4.7.3. Sample-size and sampling-techniques

64% of the-respondents, pointed-out, that Plan and Design of the-study, particularly, the-identification of representative sample-size is of concern. This-section, hence, bring more-light on the-matter.

In-empirical-quantitative-engineering-research/laboratory-testing-experiments, the-number of samples is, usually, already-explicitly-specified, in the-laboratory-manual, for a-particular-equipment. Therefore, it-is pre-determined (by-default); consequently, there-is little-concern about its-determination. On-the-other-hand, the-sample-size-determination might-be of importance in mixed-research, where both; quantitative and qualitative-methods are used, hence the-next-brief will-provide some- more-clarifications.

On-the-other-hand, calculating and justifying sample-size, for a-study, can-be a-scary-task, for new-researchers. Nonetheless, it-is one of the-most-important-aspects of any-study. For sampling to-work correctly, it-is-critical that the-sample is free from bias (members of a-population should-have, more or less, equal-chance of being included in the-sample). It-is-important to-note that, methods to-calculate sample-size, vary, depending on the-study-design. For-example, calculating sample-size for a-survey has a-different-methodology, than to-calculate sample-size for a-case control-study; however, the-fundamental principles remain the-same.

Unless it-is a-complete-census, researchers collect data, from a-selected-group, rather than an-entire-population. The-size of the-sample will-depend on-a-number of factors: time and resources available, prevalence of the-studying-conditions, and likely-response-rate (Trounson, 2011). A quantitative study involving a-comparison, between-two-groups, is likely to-require a *power calculation*, a statistical-technique to-estimate minimum-sample-size. As to the-method of selection, of the-sample, there-is a-range of well-developed-methods, to-choose-from; for-example, in-quantitative-study-designs, random-sampling is considered 'the-gold-standard'. When a-proportion of the-sample is selected-randomly, this removes selection-bias. However, this-is, only-possible, when a complete-list of the-population is available (known as the-sampling-frame). In-case a-Randomized-Controlled-Trial (RCT) is required; sample-size-calculation is needed, probably, with consultation of a-statistician.

Besides, several-statistical-software (e.g. EpiInfo, SPSS, etc.), and online-websites are available, to-help a-researcher calculating-sample (see Figure 11). However, first, a-researcher-needs to-have following four-parameters: (1) The-effect-size (reflects the-expected-difference in the-two-study-groups); (2) The-population standard-deviation (for continuous-data); (3) The-desired-power of the-experiment, to detect the-postulated-effect (the-ability to-find a-difference between-the-two groups, being studied, if there is actually a-difference. Conventionally, 80% power (or 90%, in some-cases) is taken as-standard; 80% power corresponds to a-beta-error of 20%); and (4) The-significance-level; Alpha-error of 5%, also-written as-significance-level of 95% (Boyack & Borner, 2003).

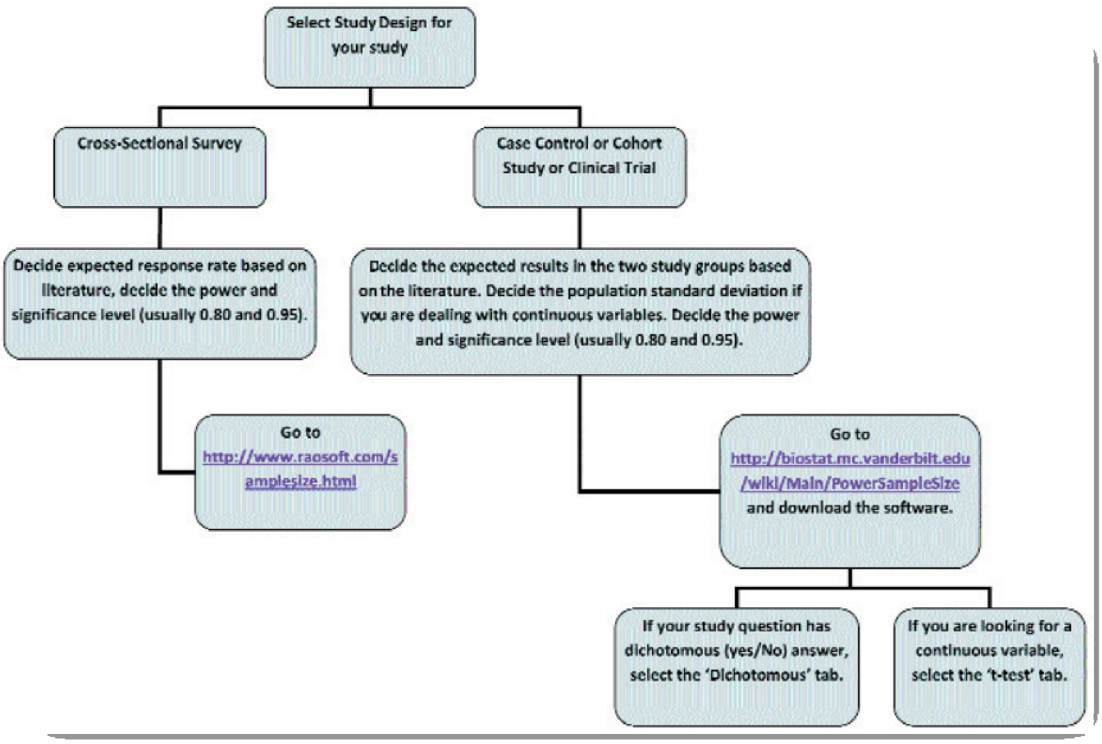


Figure 11: Calculation of sample-size (Asad-Ali, 2012).

After calculating the-required-sample-size, the-next-step is to-select an-appropriate sampling-technique; broadly-classified as probability and non-probability sampling-methods.

Probability-sampling is where, every-unit, in the-population, has a-chance (greater than zero) of being selected in the-sample, and this-probability can-be accurately-determined. Examples: (1) *Random-* selection; (2) *Systematic*-sampling (arranging the-target-population according to-some-ordering-scheme, and then selecting elements, at-regular-intervals, through that-ordered-list. It involves a-random-start and then proceeds with the-selection of every *k-th* element, from then onwards; (3) *Stratified*-sampling is used when the-study-population has number of distinct-categories or strata; each-stratum is then sampled as an-independent sub-population, out of which individual-elements can-be randomly-selected.

Nonprobability-sampling is any-sampling-method, where some-elements of the-population have-*no*-chance of selection (also referred to as 'out of coverage' or 'under-covered'), or where the- probability of selection *cannot*-be accurately-determined. Examples: *Convenience*-sampling involves the-sample, being drawn from that-part of the-study-population, which is close, to-hand. That is, a-population is-selected, because it-is readily-available, and convenient. The-researcher, using such-a sample, cannot, scientifically, make generalizations, about the-total-population, because it would not-be representative-enough (Asad-Ali, 2012).

Besides, to-produce a-quality-research, additional-issues, including good-research practices, should-be looked-into.

4.8. Good-research practices (*often overlooked*)

4.8.1. Merton's CUDOS-norms

Merton's-norms is a-good-starting-point, for a-discussion, about what-constitutes good-research-practice. Merton's CUDOS-norms are: (1) *communism*, or *communalism* (C), means that the-research-community and society, as-a-whole, have the-right to-be-informed of the-results of research. New-knowledge should *not* be-kept-secret and concealed, for non-scientific-reasons. Apparently, according to Merton, therefore, there is *no*-such-thing as 'intellectual-property', owned by the-researcher; (2) *universalism* (U) requires scientific-work, to-be-evaluated, with reference to-scientific-criteria, alone. When assessing the-validity of the-results, we are to-take *no* account, for-example, of the researcher's race, gender, age, or position, in-academia, or in-society; (3) *disinterestedness* (D) means that the-researcher must-have *no*-other-motive, for their-research, than a-desire to-contribute new-knowledge; (4) *organized skepticism* (OS), requires the-researcher to-constantly question and scrutinize, but also to-refrain from expressing an-assessment until, they, have-sufficient-evidence, on which-to-base-it. According to-Gustafsson (2006), however, the-norms are-idealistic and 'In-many-cases, Merton's norms will-be-difficult to-live up-to, in-reality'.

Furthermore, good-research requires vigilant-judgment and honesty. It carefully-evaluates information-sources. It acknowledges possible-errors, limitations and contradictory-evidence. It identifies excluded-factors or issues, that may-be-important. It describes key-decisions, researchers faced, when structuring their-analysis and explains the-choices-made. Good-research is cautious, about drawing conclusions, careful to-identify uncertainties and avoids overstated-claims. It demands multiple-types of evidence, to-reach a-conclusion (Litman, 2012).

4.8.2. Ethical-issues in research

4.8.2.1. Scientific-misconduct; errors & negligence; and conflict of interests

Research is-based on-the-same ethical-values that apply in-everyday-life, including: honesty, fairness, objectivity, openness, trustworthiness, and respect for others. One of the-paramount good-research practices is 'scientific-standard'-refers to the-application of these-values, in the-context of research.

The-most-serious-violations of scientific-research-standards are known, under the-umbrella of 'scientific-misconduct'. The U.S.A. government defines misconduct as: 'fabrication, falsification, or plagiarism (FFP) in proposing, performing, or reviewing research, or in-reporting research-results'. Besides, Moher *et al.* (2001), for-example, suggest that: 'inadequate-reporting borders on unethical-practice, when biased-results receive false-credibility'.

According to-the-statement, *Fabrication* is 'making-up data or results'; *Falsification* is 'manipulating research-materials, equipment, or processes, or changing or omitting-data or results, such that the-research is *not* accurately-represented in the-research-record'; while *Plagiarism* is 'the-appropriation of another-person's ideas, processes, results, or words, without giving appropriate-credit'. Moreover, Starovoytova & Namango (2016c), in-their-recent-study, pointed-out on complexity of plagiarism, by providing its 10 sub-types, on a-more-deeper-level, identifying their-seriousness and commonness.

In-addition, misconduct-actions must-represent a-'significant-departure from accepted-practices', must-have-been 'committed-intentionally, or knowingly, or recklessly', and must-be 'proven-by a-preponderance of evidence'. Besides, according to-the-statement: 'research-misconduct does- *not*-include differences of opinion' (NAS, 2009).

A-crucial-distinction between falsification, fabrication, and plagiarism (FFP) and error or negligence, is the-*intent* to-deceive. When researchers, intentionally, deceive their-colleagues by: falsifying-information, fabricating research-results, or using others' words and ideas, without-giving-credit, they-are-violating fundamental-research-standards, as-well-as the-basic-societal-values.

Scientists, who-violate-standards, other than FFP, are said to-engage in 'questionable research-practices'. Standards apply, throughout the-research-enterprise, but 'scientific-practices' can-vary, among-disciplines, departments or laboratories. Understanding, both; the-underlying-standards and the-differing practices, in-research, is-important to-working-successfully and effectively, with-others.

On-the-other-hand, according to Starovoytova& Namango (2017), who cited a-study by Benos (2005), plagiarism, itself, contributes only a-small-percentage (7%), in the-array of ethical-issues in publications, such-as (in decreasing-order of input): redundant-publications; animal-welfare-concerns; authors' disputes; duplicate-publications; human-welfare-concerns; data-fabrication; conflicts of interest; and reviewers' bias and submission-irregularities.

Every-step of the-research-study is imperative; negligence and/or mistakes, in-any-step, can affect the-complete-study and not just that-part. All-researchers are human-beings; on the-other-hand, 'to-error is-human', hence, all-scientific-research is inherently-predisposed to-error. Even the-most-responsible researcher can-make an-honest-mistake: in-the-design of an-experiment, in-the-calibration of instruments, in-the-recording of data, in-the-interpretation and reporting of results, or any-other-aspects of research.

Beyond honest-errors, are-mistakes, caused-by-negligence. Hurriedness, carelessness, inattention, and alike, can lead to-substandard-work, which does *not* meet scientific-standards, or the-practices, of a-discipline. Researchers, who-are-negligent are placing their-reputation, the-work of their-colleagues, and the-public's confidence, in-Science, at-risk.

When a-paper is found to-contain *errors*, whether caused by-mistakes or deceit, the-authors should-take a-professional-responsibility, for-the-material, in-question. Some-mistakes in-the-scientific- record are quickly-corrected, by-subsequent-work; some, however, can mislead subsequent-researchers, causing waste of large-amounts of both; time and resources. When, such-mistake, appears-in a-journal article, or book, it-should-be-corrected: in-a-note, '*erratum*' (for a-production-error), or '*corrigendum*' (for an-author's error). Mistakes in other-documents, that are part of the-scientific-record, such as: research-proposals, laboratory-records, progress-reports, abstracts, theses, and internal-reports; should-be corrected in-a-way that maintains the-integrity, of the-original-record, and at-the-same-time keeps other researchers, from building on the-erroneous-results, reported in-the-original.

Within the-scientific-community, the-effects of misconduct, such-as: lost-time, damaged reputations, and feelings of personal-betrayal; can-be-devastating. Individuals, institutions, and, even, entire research-fields, can-suffer serious-setbacks, from instances of fabrication, falsification, and plagiarism. Acts of misconduct, also can-draw the-attention of the-media, policymakers, and the-general-public, with negative-consequences, for all of Science and, eventually, for the-public, at-large; therefore they should-be highly-discouraged and avoided, as-much-as-possible.

4.8.2.2. Conflict of interest.

In-the-17th-century, many-scientists, including Isaac Newton, kept new-original-discoveries a-secret, so that others could-*not*-claim the-results, as their-own.

Intellectual-property-rights (IPRs) is a-legal-framework for protecting and controlling the- application of an-idea, in a-specific-context (through a-patent; copyright; trade-secret; and trade-mark). Most-research-institutions, including MU, have intellectual-property-policies. These-policies may-specify how research-data are collected and stored, how and when results can-be-published, how intellectual property-rights can-be transferred, how patentable-inventions should-be-disclosed, and how Royalties from patents are-allocated. Also, patent-law differs from country-to-country, hence researchers need to familiarize themselves with (IPRs)'-specifics of a-particular-institution/research-organization.

Besides, researchers, do-have many-interests, such-as: personal, intellectual, financial, and professional, among-others. These-interests, often-coexist, in-tension; sometimes, they, even, clash. The expression 'conflict of interest' refers to-situations, where researchers-have-interests that could-interfere with their-professional-judgment. Managing these-situations is essential, in-maintaining the-integrity of researchers and Science, as a-whole.

Financial-conflicts of interest, receive particular-attention, in-science. Researchers, generally, are entitled to-benefit, financially, from their-work; for-example, by receiving Royalties on inventions, or bonuses from their-employers. But, at-times, the-prospect of financial-gain could-manipulate and re-shape the-design of an-investigation, the-interpretation of data, or the-presentation of results. In fact, even, a-suspicion, of a-financial-conflict of interest, can-seriously-harm a-researcher's reputation, as-well-as, public-perceptions, of Science.

Conflicts of interest, though, should-be distinguished-from *conflicts of commitment*. Researchers, have-to-make-intricate-choices, about how-to-divide their-time, between research, and their-other numerous-responsibilities. Conflicts between these-commitments, can-be a-source of considerable-tension, in a-researcher's life, and can cause problems, in their-career. Managing these-responsibilities is rather- challenging, but different from managing conflicts of interest.

Beyond conflicts of interest and commitment, are issues, related to the-values and beliefs, that researchers embrace strong philosophical, religious, cultural, or political-beliefs, that could-influence, their- scientific-judgments. Hence, values that compromise objectivity and introduce-bias, into-research must-be recognized and minimized.

4.8.2.3. Storage of data; Human and animal-subjects; and laboratory-safety.

Whole-books are devoted to the-subject of safe-keeping of research-data; this-brief, logically, will *only* touch at the-tip of an-iceberg.

The-various-data and samples, collected in the-course of a-research-project, are-referred-to-as *source*, or primary (raw)-data. They-may consist of instrument-output, from laboratory-testing-experiments; original-questioner-responses; astronomical-images from space-telescopes; X-ray-images, from hospitals; tape-recordings of interviews, results of large-scale computer-simulations, soil-samples, fibre-samples, tissue-samples, and so-on. Many-researchers put an-enormous-effort into-gathering such-material. At many-departments, researchers regard their-source-data, as their-personal-property; the-sources, therefore, should-be-kept, safely and appropriately.

In-particular, paper-copies and tapes need-to-be locked in a-cabinet, or drawer, to-preserve confidentiality, and electronic-records need-to-be-stored on a-secure-computer and backed-up, on a-separate-disk, or server. Besides, due to rapidly-changing digital-technologies, some-data, stored electronically, may-be inaccessible in a-few-years, unless provisions are-made, to-transport the-data, from one-platform to-another (Pascal, 2006). Many-researchers preserve both; paper and electronic-records, as either can-be destroyed or corrupted, by unexpected-events, such-as: fire, theft, flood, an-accidental damage or computer-breakdown, among-others. On-the-other-hand, if data are altered, it can lead to-misleading the-colleagues and potentially hamper the-progress, in that-field or research; besides it-could undermine the authority and trustworthiness of reporting-researchers.

Depending on the-field, sometimes, data have to-be-entered into bound-notebooks (with sequentially-numbered-pages) using permanent-ink, using a-computer-application, with secure-data entry fields, identifying when and where the-work-was-done, and retaining the-data, for specified-lengths of time. Besides, in-most-industrial-research and in-some-academic-research, data-notebooks, need-to-be signed and dated, by a-witness, on-a-daily-basis. Regrettably, beginning-researchers often-receive little or *no* formal-training, in: recording, analyzing, storing, or sharing-data.

From the-observations and personal-experience, the-procedures, for archiving and keeping the-source-data, are, yet, to-be-established, at the-SOE. In-this-regard, such-procedures have-to-be-put in-place and maintained by the-departmental-managers, as it-can-hardly be-regarded as the-responsibility of the-individual-researcher or research-team, alone. In-addition, regularly-scheduled-meetings, to-discuss data-issues and policies, maintained by-research-group(s) and the-institution, can-establish clear expectations and responsibilities, of every-member of the-research-team.

4.8.2.4. Research on human and animal-subjects; and issues of laboratory-safety

Carrying-out-research on *human subjects* throws-up certain-ethical-issues; main-ones are: confidentiality and anonymity of the respondents/subjects/participants, which-are-exposing, at-times, highly-sensitive information, about themselves. Besides, any-scientist who conducts research, with human-participants, needs to-protect the-interest of research-subjects, by complying with relevant-regulations and codes, established by-professional-groups. These-provisions are-designed, to-ensure that risks to-human- participants are minimized; that risks are reasonable, given the-expected-benefits; that the-participants, or their authorized-representatives, provide informed-consent; that the-investigator has-informed participants of key-elements of the-study-protocol; and that the-privacy of participants, and the-confidentiality of data, are-maintained. At a-minimum, anyone who engages in-research, that involves humans, must-be-aware of all-relevant-regulations and have-appropriate-training.

The-use of *animals*, in-research and research-training, is-also subject to-regulations and professional codes (to-insure that animals, intended for use, in research-facilities, are provided humane-care and treatment).

In-addition to human-participants and animal-subjects, in-research, professional-guidelines and regulations cover other-aspects of research, including the-use of grant-funds, the-sharing of research-results, the-handling of hazardous-materials, and laboratory-safety.

These-last-two-issues are sometimes-overlooked, in-research, but *no* researcher or scientific- discipline is immune, from-accidents. An-estimated half-million-workers, in the-U.S.A., alone, handle hazardous biological-materials, every-day. An-explosion in March, 2006 at the-National-Institute of Higher-Learning-in-Chemistry, in Mulhouse, France, killed a-distinguished-researcher and caused USD130 million, in-damage (Gustafsson *et al.,* 2006). Researchers-should-carefully-review information and procedures, about safety-issues, at-least-once a-year (on appropriate-usage of protective-equipment and clothing; safe-handling of materials, in-laboratories; safe-operation of equipment, and safe-disposal of materials; hazard-assessment-processes; safe-transportation of materials, between laboratories; emergency-responses; and safety-education of all-personnel, before-entering-the-laboratory or before starting-experiments, on a-new-equipment).

5. Conclusion and recommendations.

5.1. Conclusion

The-major-findings of this-study pointing-out on several-stages of the-research-process, where the participants experienced particular-difficulties; they also-indicated the-most-important-ways to-increase the-number and the-quality of publications. In-addition, some-misconceptions, regarding: (1) the-*quality*-aspect of research; and (2) qualitative-research, and its value, to-engineers-researchers; were identified.

The-fundamental-values, on which Science and Engineering are based, including *honesty, fairness, respect for others,* and *ingenuousness*, serve as directions of conduct, in-everyday-life, as-well-as, in- research. The-author trusts, this-paper contributes (in its-small-way) to a-deeper-understanding on research and its-quality; and also have-a-say in-continuous-deliberation, about subject-matter, by engineering academic-faculty.

5.2. Recommendations

The-following recommendations (previously-mentioned, in-the-paper) are summarized, as-follows:

1) In-the-view of possible-shift, in-global-dominance of research, Kenya should-establish its-own-niche, concentrating more on *real*-economic-problems, it-currently-faces.
2) Researchers should-strive conducting an-ethical-research of high-quality. Scientific misconduct, of any-sort, therefore they should-be highly dejected.
3) Researchers also-need to-be-encouraged to-publish-more, in-internationally visible-research-outlets, which are largely-indexed, either in Scopus, or TR-WoS, or in-both.
4) The-procedures, for archiving and keeping the-source-data, have-to-be-put in-place, and maintained by the-departmental-managers. In-addition, regularly-scheduled-meetings, should discuss data-issues and policies, maintained by-research-group(s) and the-institution, establishing clear-expectations and responsibilities, of every-member of the-research-team.

6. Acknowledgment

The-authors would-like-to-thank, all-the-participants, SOE, for their-time, and willingness to-contribute, to this-concise, *unfunded*-study.

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