PRINCIPLES OF ENGINEERING RESEARCH

By

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INTRODUCTION:

The Engineering profession is a most noble profession that requires years of training in order to equip the practitioners with the requisite knowledge and competencies for effective dispatch of their duties. It is often said that when a medical Doctor makes a mistake, somebody dies, but not so with an Engineer; for when an Engineer makes a mistake, multitudes die.

It is for this reason that the engineering training is both rigorous and approached with all the seriousness it deserves. A fundamental part of that training is administered through apprenticeship in the form of **engineering research**.

DEFINITIONS:

Engineering is essentially concerned with the development of ideas, processes, materials, and devices aimed at improving the lives of people [1].
According to Malpas in [2] Engineering can be defined as "*the process of assembling knowledge and experience to create machines, devices, systems, structures, processes and products to meet human needs - and to improve and extend those previously created*."

Research is a systematic process of collecting and analysing data with the aim of finding an answer to a question, solution to a problem, or to test an existing theory with a view to validating it.
It can also be defined as a careful and systematic study in a field of knowledge, embarked upon to discover facts or principles.

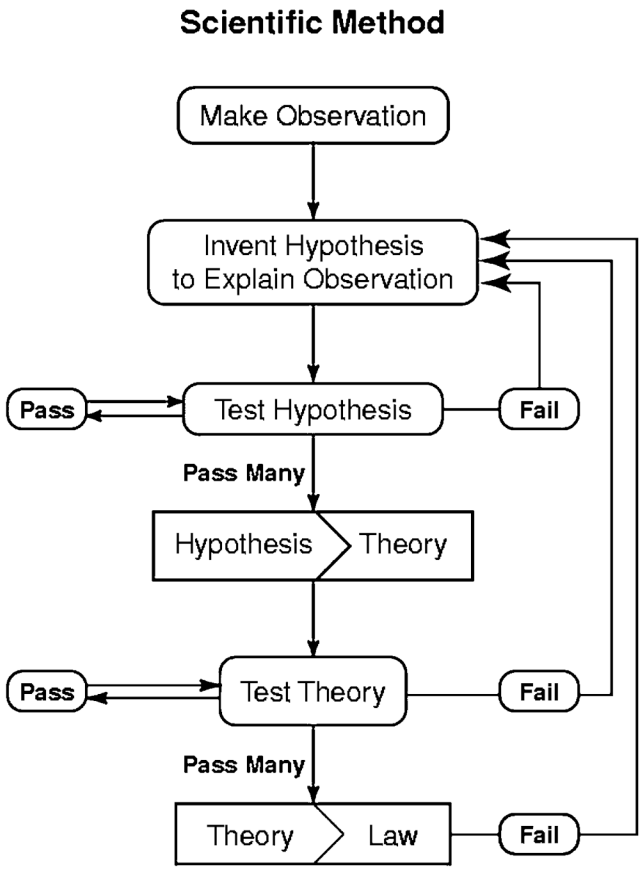
Engineering Research

From the foregone, it follows naturally that **engineering research** is necessarily devoted to investigating new ways of arriving at the ideas, through time-tested processes involved in the development of new materials on the basis of known and existing ones. These materials are in turn engaged in the development of new devices that improve the lives of people.

In Malpas' view, **engineering research** has as its objective the seeking of fundamental understanding to improve the engineering process. In his opinion, the end product of **engineering research** is *'the development of new or improved techniques and processes for creating machines and devices etc., with better specifications and/or lower costs, and the machines and devices etc. themselves'*. This end product he aptly termed **technology** [2].

Science on the other hand can be defined broadly as *'the knowledge and understanding of the character and behaviour of everything that exists, be it natural or manmade*.'
The scientific knowledge is usually gotten through the process of observation, experimentation, and analysis of experimental results. This is known as **the scientific method** [2].
It is worthy of note that unlike engineering, practical use is not an objective of the scientific method.

THE SCIENTIFIC METHOD:
The **scientific method** is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge [3].



Source: [4]

Stages of the Scientific Method
1. Observation and Description of a phenomenon
2. Formulation of an Hypothesis to explain the observed phenomenon
3. Use of Hypothesis to predict existence of other phenomena
4. Design & Performance of experiments to test the prediction
5. Logical conclusions:
    a. If experimental results corroborate hypothesis, it becomes a theory
    b. Conversely, if experimental results do not corroborate hypothesis, it is rejected or modified.

A **hypothesis** is an unproven, albeit *logical* explanation for an observed phenomenon.

A **scientific hypothesis** is a testable hypothesis using the tools of the scientific method. A scientific hypothesis is a proposed explanation of a phenomenon, which still has to be rigorously tested. It is not the same as a scientific theory.

A **working hypothesis** is a hypothesis credible enough to be acceptable for proposed future research.

A **scientific theory** has undergone extensive testing and is generally accepted to be the accurate explanation behind an observation [5].

The scientific method distinguishes science from other forms of explanation because of its requirement of systematic experimentation [6].

PURPOSE OF ENGINEERING RESEARCH:

The main objective of engineering research is to improve on current engineering processes and techniques. To this end, the scientific method is engaged with the sole aim of practical application at heart:

1. Generate new or validate existing theories
2. Isolate and study the cause as well as effect of a phenomenon
3. Answer questions and make logical decisions that culminate in improving the quality of living.

TYPES OF ENGINEERING RESEARCH:

1. **By Application:**
    a. Pure - For the sake of knowing (Esoteric)
    b. **Applied -** For application of research findings in meeting engineering needs through application to real life cases
2. **By Design:**
    a. Pre-experimental
    b. Quasi-experimental
    c. Experimental.
3. **By Purpose:**
    a. Descriptive
    b. Exploratory
    c. Causal
    d. **Developmental … .**

ENGINEERING CODE OF ETHICS

The fundamental principles of engineering research are as enshrined in the engineering code of ethics. The fundamental principles of the code form the basis on which the fundamental canons ride.

Irrespective of the diversities across engineering disciplines, the code of ethics is as similar as it is universal to a large extent. Using the American Society of Civil Engineers as an example, the code of ethics can be as given below:

Fundamental Principles:

It is the duty of every Engineer to uphold the integrity, honor and dignity of the profession. This they achieve by:

1. Application of acquired knowledge and skill for the betterment of human welfare;
2. Exhibiting honesty and serving the public, their employers and clients with fidelity;
3. Always striving to improve the competence and prestige of the engineering profession; and
4. Supporting the professional and technical societies of their disciplines. [7]

Fundamental Canons:

1. "Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.
2. Engineers shall perform services only in areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession and shall act with zero-tolerance for bribery, fraud, and corruption.
7. Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision." [7]

CONCLUSION:

Engineering research rests squarely on the processes of scientific research and method, however, while scientific research is not always aimed at culminating in practically useable results, this is almost always the objective of engineering research. Since by definition, the field of engineering is concerned with the development of processes, devices, *etcetera* for improving the quality of human life. The engineering code of ethics is very influential in the whole process of engineering research as it lays the ethical basis for professional development throughout the career of an engineer (canon 7).

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PRINCIPLES OF ENGINEERING RESEARCH

SCHOOL OF POSTGRADUATE STUDIES
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Vision of Covenant University

To be a leading **World-Class** Christian Mission **University**, committed to raising a new generation of **leaders in all fields of Human endeavour**.

Mission of Covenant University

To create knowledge and restore the dignity of the black man via a Human Development Total Man Concept driven curriculum **employing innovative**, leading-edge teaching and learning methods, **research** and professional services that promote integrated, **life-applicable** , life-transforming education, relevant to the context of **Science, Technology** and Human Capacity Building.

INTRODUCTION

- The Engineering profession is a most noble profession
- Requires years of training in order to equip the practitioners with the requisite knowledge and competencies for effective dispatch of their duties.
  - Medical Doctor errs – ***somebody*** dies;
  - Engineer errs – ***Multitude*** perish.
- Engineering training is both rigorous and approached with all the seriousness it deserves.
- A fundamental part of that training is administered through apprenticeship in the form of **engineering research**.

DEFINITIONS: *Engineering*

- concerned with the development of ideas, processes, materials, and devices aimed at improving the lives of people [1].
- "the process of assembling knowledge and experience to create machines, devices, systems, structures, processes and products to meet human needs - and to improve and extend those previously created." [2]

Research

- Systematic process of collecting and analysing data with the aim of:
  - finding an answer to a question,
  - solution to a problem, or
  - test an existing theory with a view to validating it.
- It can also be defined as a careful and systematic study in a field of knowledge, embarked upon to discover facts or principles.

Engineering Research

- **Engineering research**
  - devoted to investigating new ways of arriving at the ideas,
  - through time-tested processes involved in the development of new materials
  - These materials are in turn engaged in the development of new devices
  - With the ultimate aim of improving the lives of people.

Engineering Research *Malpas et al*

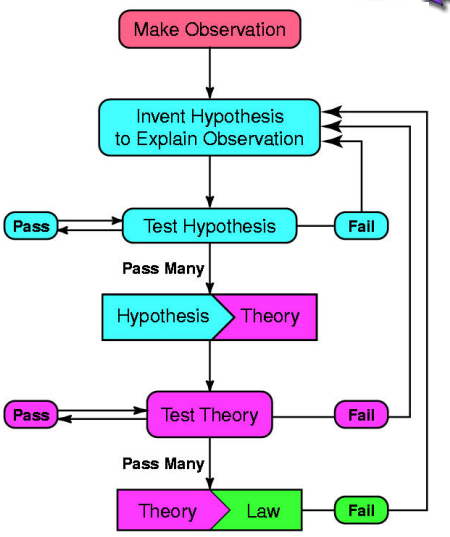
- **Engineering Research** [*Malpas*]
  - has the objective of seeking fundamental understanding ***to improve the engineering process***.
  - end product of **ER** is "*the development of new or improved techniques and processes for creating machines and devices etc*.,
  - with better specifications and/or lower costs, and the machines and devices etc. themselves'.
  - This end product he aptly termed **technology** [2].

Science

– 'Knowledge and understanding of the character and behaviour of everything that exists, be it natural or manmade.'
– Scientific knowledge is usually gotten through:
  • the process of observation,
  • experimentation, and
  • analysis of experimental results.
– This is known as **the scientific method** [2].
– Worthy of note that practical use is not an objective of the scientific method.

The Scientific Method

• A body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge [3]



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Elements of the Scientific Method

- A **hypothesis** is an unproven logical explanation for an observed phenomenon.
- A **scientific hypothesis** is a testable hypothesis using the tools of the scientific method.
- A **working hypothesis** is a hypothesis acceptable for proposed future research.
- A **scientific theory** has undergone extensive testing and is generally accepted to be the accurate explanation behind an observation.
- A **scientific law** is a distillate of the result of repeated observations.

Engineering Research: Purpose

- The main objective of ***ER*** is to improve on current engineering processes and techniques
- The scientific method is engaged with the sole aim of practical applications:
  - Generate new or validate existing theories
  - Isolate and study the cause as well as effect of a phenomenon
  - Answer questions and make logical decisions that culminate in improving the quality of living.

ENGINEERING CODE OF ETHICS

- The fundamental principles of ***ER*** are enshrined in the engineering code of ethics.
- The fundamental principles of the code form the basis on which the fundamental canons ride.
- the code of ethics is as similar for ALL engineering disciplines as it is universal to a large extent
- *Example:* American Society of Civil Engineers code

THE CODE: Fundamental Principles

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CONCLUSION

- Engineering research rests squarely on the processes of scientific research and method,
- while scientific research is not always aimed at culminating in practically useable results, this is almost always the objective of engineering research.
- The engineering code of ethics is very influential in the whole process of engineering research as it lays the ethical basis for professional development throughout the career of an engineer (canon 7).

THANK YOU!