CHAPTER

1 RESEARCH AND DESIGN

INTENDED LEARNING OUTCOMES (ILOs)
At the end of this chapter, the student is expected to:
• Define research in relation to its goals and purpose;
• Classify and differentiate the different types of research;
• Demonstrate the characteristics of a good research problem as well as that of a good design; and
• Differentiate research with design.

This chapter may be completed in a span of three (3) hours.

The Meaning of Research

The meaning of research as well as its attributes and characteristics are the same regardless of the learning discipline or field of study. Hence, the common definition of research is hereby adopted, thus: *Research is simply a systematic and refined technique of thinking, employing specialized tools, instruments, and procedures in order to obtain a more adequate solution to a problem than would be possible under ordinary means.*[1]

Oxford Concise Dictionary defines research as a systematic investigation into and study of materials, sources, etc, in order to establish facts and reach **new conclusions**. It is an endeavour to discover new or collate old facts, etc., by the scientific study of a subject or by a course of critical investigation (emphasis supplied).

Purpose of Research

The purpose of research is *to serve man* and the goal of research is good life, to satisfy man's craving for more understanding, to improve his judgments, to add to his power, to reduce the burden of work, to relieve suffering, and to increase the satisfaction in multitudinous ways - these are the large and fundamental goals of research.[2]

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[1] C.C. Crawford, The Elements of Research. (New York: Prentice-Hall, Inc., 1946)

[2] Carter Good and Douglas Scales, Methods of Research Educational, Psychological, Sociological. (Manila: Appleton-Century-Crafts, Inc., 1972)

From the purposes of research stated above, to "ease the burden of work" is the most common aim of computing researchers.

Characteristics of Research[3]

The following are the generally accepted characteristics of research:

1. **Empirical**. Research is based on direct experience or observation by the researcher. The collection of data relies on practical experience without benefit of the scientific knowledge or theory.
2. **Logical.** Research is based on valid procedures and principles. Scientific investigation is done in an orderly manner so that the researcher has confidence on the results. Logical examination of the procedures used in the research enables the researcher to draw valid conclusions. Thus, the logic of valid research makes it important for decision making.
3. **Cyclical.** Research is a cyclical process. It starts with a problem and ends with a problem. For instance, a researcher who completes his study states his findings and draws up his conclusions and recommendations. In his recommendations, many problems may crop up as other subjects for study hence, the cycle is repeated.
4. **Analytical**. Research utilizes proven analytical procedures in gathering the data, whether historical, descriptive, experimental or case study.
5. **Replicability.** The research designs and procedures are replicated to enable the researcher to arrive at valid and conclusive results. Similarities and differences of replicated researches can be compared. The more replications, the more valid and conclusive the results would be.
6. **Critical.** Research exhibits careful and precise judgments. A higher level of confidence must be established, i.e., at one percent or five percent level of confidence.

Types of Research[4]

Basically, there are three types of research; **pure research, applied research** and **action research**.

1. **Applied Research** involves seeking new applications of scientific knowledge to the solution of a problem, such as the development of a new system or procedure, new device, or new method in order to solve the problem.

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[3] Laurentina Calmorin and Melchor Calmorin, Methods of Research and Thesis Writing. (Manila:Rex Book Store,1995)

[4] Laurentina Calmorin and Melchor Calmorin, Methods of Research and Thesis Writing, Page 10-12Appleton-Century-Crafts, Inc., 1972)

It refers to the application of theory to the solution of problems. It is conducted for the purpose of applying, or testing theory, and evaluating its usefulness.

Example: Development and Evaluation of a Visual Room Scheduler for the Technological Institute of the Philippines using Artificial Intelligence

2. **Action research** is a feature of applied research, which is a decision-oriented research involving the application of the steps of the scientific method in response to an immediate need to improve existing practices. Action research is focused on immediate application, not on the development of a theory or on generalization of applications. The researcher is required to do some "action" such as teaching the respondents how to use a particular device, teaching the importance of a particular subject, etc.

   Example: Methods of birth control.
   Vaccination

3. **Pure Research** aims to discover basic truths or principles. It is intended to add to the body of knowledge by exploring the unknown, to extend the boundaries of knowledge, as well as to discover new facts. It is conducted primarily to test or arrive at a theory. Its main objective is to establish general principles without known or intended practical application of the findings.

   Example: Newton's Law (Finished)
   The function and importance of an appendix.

Research Methods[5]

A research methodology defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success. This is how most graduate schools define research methods. This book provides four (4) research methods, thus:

1. **Descriptive research**. It describes **what is**. It involves the description, recording, analysis, and interpretation of the present nature, composition or processes of phenomena. The focus is on prevailing condition.

2. **Historical Research**. A process of selecting the area or topic to write the history about, collecting data about events that occurred in the area or about the topic, collating the data, sifting the authentic from non-authentic, and then making an interpretative narrative about or critical inquiry into the whole truth of the events. Historical research describes what occurred in the past and makes a critical inquiry into the truth of what occurred.

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[5] Gaudencio Aquino, Essentials of Research and Thesis Writing (Manila: Alemars-Phoenix Publishing House, Inc., 1974);

3. **Experimental Research.** A problem-solving approach that describes the effect when certain variables are carefully controlled or manipulated. It focuses on the **past, present** and **future conditions**.

4. **Ex post Facto Research**. In this method, the researcher investigates a problem by studying the variables in retrospect. It is a research in which the dependent variable is immediately observable and the main concern is to find out the antecedents that gave rise to this consequence.[6]

5. **Case Study Research.** According to Bromley (1990), it is a systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest.

The Meaning of Design

In the area of engineering, *design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.*[7]

Thus, in the area of Computing or Information Technology Education (ITE), the term design includes, among others, (1) application development that focuses on software engineering processes or (2) application design that focuses on effective testing procedure or (3) a study on application development processes, in which basic sciences, mathematics and computing are applied to meet the stated needs.

The key word in design is the word "optimum." Good designs convert and/or uses IT resources optimally to meet the stated needs. It is for this reason why the Commission on Higher Education (CHED) defines the Bachelor of Science (BSIT) program as the study of the **utilization** of both hardware and software technologies in planning, installing, customizing, operating, managing, administering and maintaining IT infrastructure that provides computing solutions to address the needs of an organization. The same is true with the Bachelor of Science in Entertainment and Multimedia Computing (BSEMC). In the BS Information Systems (BSIS) program, the terminal step for design is when the system, particularly the information system, has been integrated and implemented in the business processes of an enterprise. Of course, the process will be iterative for the reason that design no matter how carefully crafted and made is not perfect. Considering that the term "Research" and "Design" are two (2) different terms, the authors humbly submit that the term research is the applicable term for the Bachelor of Science in Computer Science (BSCS) program because the latter is a research-based program and hence, thesis is a requirement. The term design, on the other hand is the applicable term for the BSIT, BSIS and BSEMC programs because these programs require capstone projects.

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[6] Consuelo Sevilla, et al., An Introduction to Research Methods (Manila: Rex Book Store, 1984)

[7] ABET, Criteria for Accrediting Engineering Programs (2015)

According to Reeves (1992), everything will be a part of the design process: coding is design, testing and debugging are parts of design, and what we typically call software design is still part of design. Software may be cheap to build, but it is incredibly expensive to design. Software is so complex that there are plenty of different design aspects and their resulting design views. The problem is that all the different aspects interrelate (just like they do in hardware engineering). It would be nice if top level designers could ignore the details of module algorithm design. Likewise, it would be nice if programmers did not have to worry about top level design issues, when designing the internal algorithms of a module. Unfortunately, the aspects of one design layer intrude into the others. The choice of algorithms for a given module can be as important to the overall success of the software system as any of the higher level design aspects.

Reeves further states that there is no hierarchy of importance among the different aspects of a software design. An incorrect design at the lowest module level can be as fatal as a mistake at the highest level. A software design must be complete and correct in all its aspects, or all software builds based on the design will be erroneous.

Research and Design Distinguished

Ashley Karr (2013) distinguished research and design in this wise, thus:

To research something is to investigate it systematically. We do this in order to reach new conclusions, establish new facts, and learn as much about the truth as possible. Research also gives us a chance to find problems that we can potentially fix. We research to understand the world.

To design something is to create the form and function of an object, system, or interaction. We do this in order to make our experience here on earth (or in space) better, safer, healthier, more comfortable, more fun —and we can create solutions to the problems we found during our research. We design to change the world.

Simply stated, we research to explain WHY THINGS happen; we design in order TO MAKE THINGS HAPPEN.

The Gray between Design and Research

The American Society for Engineering Education (2006) explains the difference between research and designs in this wise, thus:

Design is NOT research, which may be defined as "a careful investigation or study, especially of a scholarly or scientific nature. A design task may require research to accomplish a task, but it typically involves the integration of knowledge, not the creation of knowledge." Design is different than research. Design considers alternative solutions by selecting the optimal solution with a fixed goal or specifications in mind. Design often results in a commercial product being developed. Research has an open-ended goal and is exploratory, with no set specifications in mind, and does not necessarily result in a product or a service.

Illustration:

Research and design can be easily explained in the following situation. Suppose you are the Light Rail Transit (LRT) administrator and you are tasked to operate the LRT in such a manner that you will incur lower expenses but will give the highest revenue.

If your organization does not have any data as to what day and time of the week will there be less passengers as well as the day and time of the week, where there will be numerous passengers, then you have to conduct a research. In this phase of research, the researcher will use the traditional data gathering procedures. After conducting this procedure, the researchers will come to understand why there are so many passengers during 7:30 to 8:30AM and why there are less passengers during 2:00PM. Recall that we conduct research to UNDERSTAND THE WORLD. In this phase, we already understand the problem.

However, if you already have such data, all you have to do is to make an appropriate scheduling system so that you employ a significant number of trains during the time of the day, where there are numerous passengers.

In the first situation wherein the organization does not have any historical data, the LRT administrator needs to do both research and design, while in the second situation where historical data is already available, he only needs to do a design.

Hence, a research work is different from design. In the foregoing paragraphs, a research work is needed to make a good design. In practical application, a person may directly do a design without conducting a research because his design may be predicated by a previous research done by others.

A final design may need initial research and a final conclusion in research may need an initial design. Research and design may be recursive with each other. There are many research outputs which will lead to design and some designs which will lead to research.

Design under the phraseology of social science research is equivalent to applied research. However, in computing and engineering parlance, an applied research is just a design. The authors subscribe to the phraseology of the computing and engineering profession because strictly speaking, only pure research can be considered as research in the real sense of the word.

The Research vs. Design Problem

A research problem is commonly defined as any significant, perplexing and challenging situation, real or artificial, the solution of which requires reflective thinking. A good research problem should be (1) **Specific**, (2) **Measurable**, (3) **Achievable**, (4) **Realistic**; and (5) **Time bound.**

Research	Design
It must be new.	It does NOT need to be new.
It does not have to be good.	It has to be good.
In sum, research does not have to be good but it must be new.	In sum, design does not have to be new, but it must be good.
It is done to understand the world.	It is done to change the world.

Let us assume that the following are the only sorting algorithms that exist, thus:

1. Bubble Sort
2. Quick sort
3. Insertion Sort
4. Selection Sort

Suppose you were able to write a sorting algorithm, say, *Hula Sort*, which uses other means and methods other than the above-mentioned sorting algorithms; your algorithm shall be considered as new. Altogether, if the running time of such new algorithm is slower than any of the above algorithms, the same may be considered a research work because it is new.

Hence, the best research output solves problems that are not only new but is worth solving; while the best design exceeds its predecessors (previous design) by using new or better ideas and/or methods.

Design and programming are human activities; forget that and all is lost.

- B. Stroustrup