WOX7001 – RESEARCH METHODOLOGY

Topic 4 – Quantitative Research

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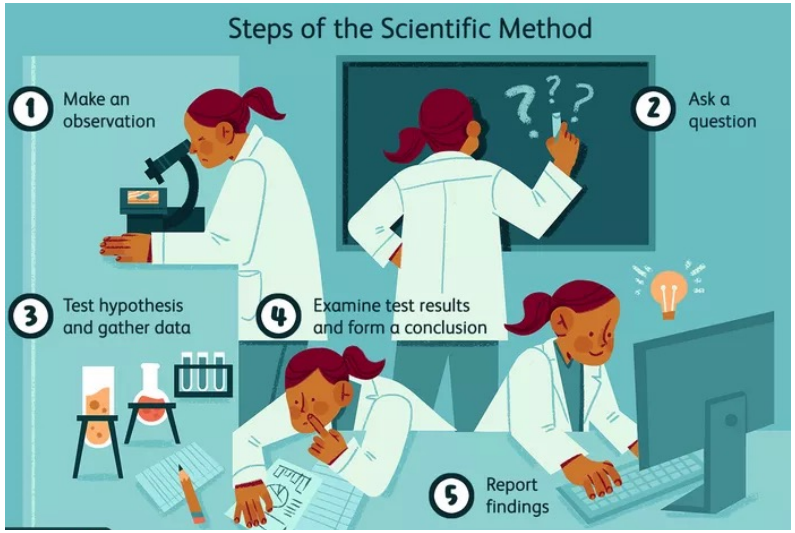
Scientific method

- The scientific method is the process of objectively establishing facts through testing and experimentation.
- Scientists use observations and reasoning to develop technologies and propose explanations for natural phenomena in the form of hypotheses
- Predictions from these hypotheses are tested by experiment and further technologies developed
- Any hypothesis which is cogent enough to make predictions can then be tested reproducibly in this way
- Once it has been established that a hypothesis is sound, it becomes a theory.



Elements of Scientific Method

- Characterisations (Quantifications, observations and measurements)
- Hypotheses (theoretical, hypothetical explanations of observations and measurements)
- Predictions (reasoning including logical deduction from hypotheses and theories)
- Experiments (tests of all of the above)

The process involved in deriving the scientific method….

- Deductive reasoning (proceeds from our knowledge of the world (theories) and predicts 'likely' observations

Example:

– Assume we know that A implies B.

– A has been observed.

– Then we should also obverse B.

OFTEN LEAD TO NEW KNOWLEDGE

The process involved in deriving the scientific method….

- Abductive reasoning (proceeds from observations to causes).

Example:

– The phenomenon X is observed.

– Among hypotheses A, B, C, and D, only A and B are capable of explaining X.

– Hence, there is a reason to assume that A or B holds.

USEFUL FOR HYPOTHESIS GENERATION

The process involved in deriving the scientific method….

- Inductive reasoning (proceeds from a set of observations to a general conclusion)

Example:

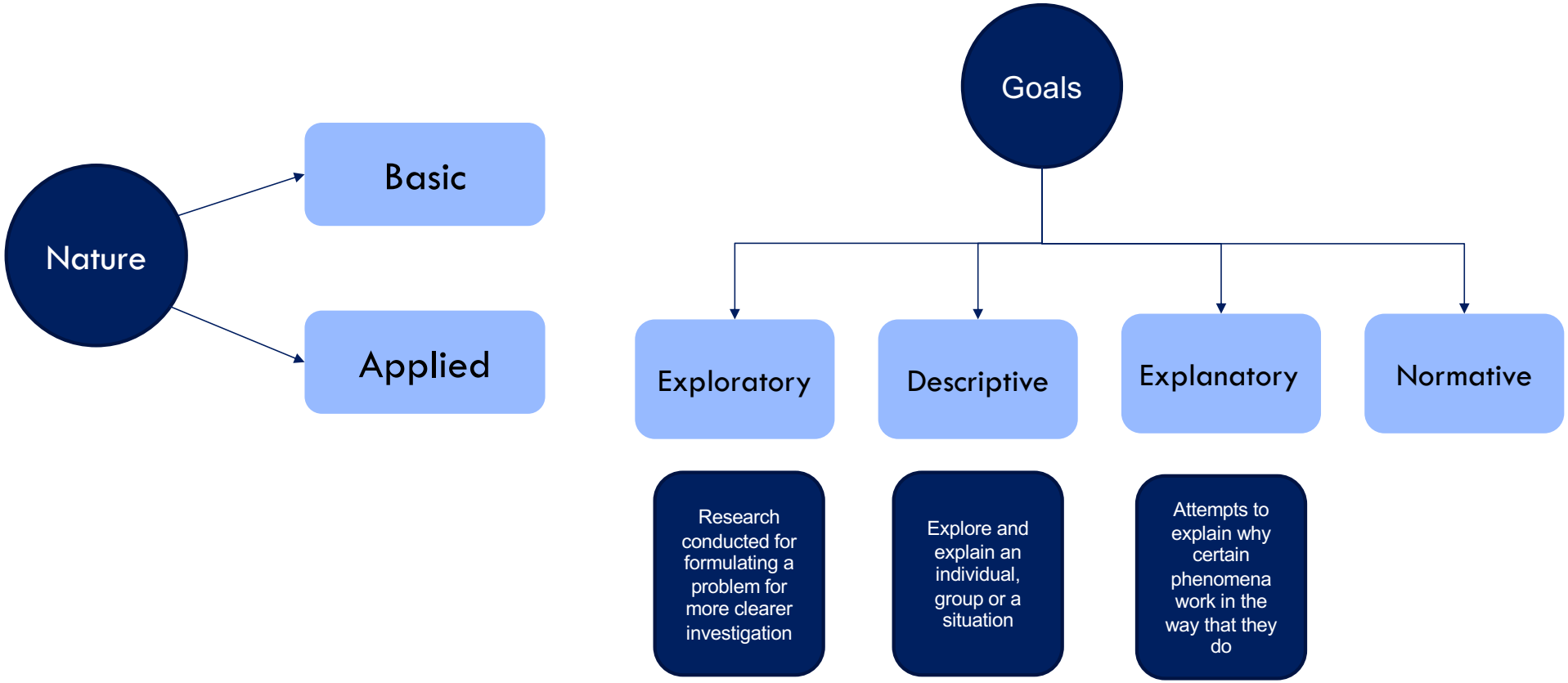
– Tycho Brahe, a 16th century astronomer, collected data on the movement of the Mars.

USEFUL FOR THEORY FORMATION

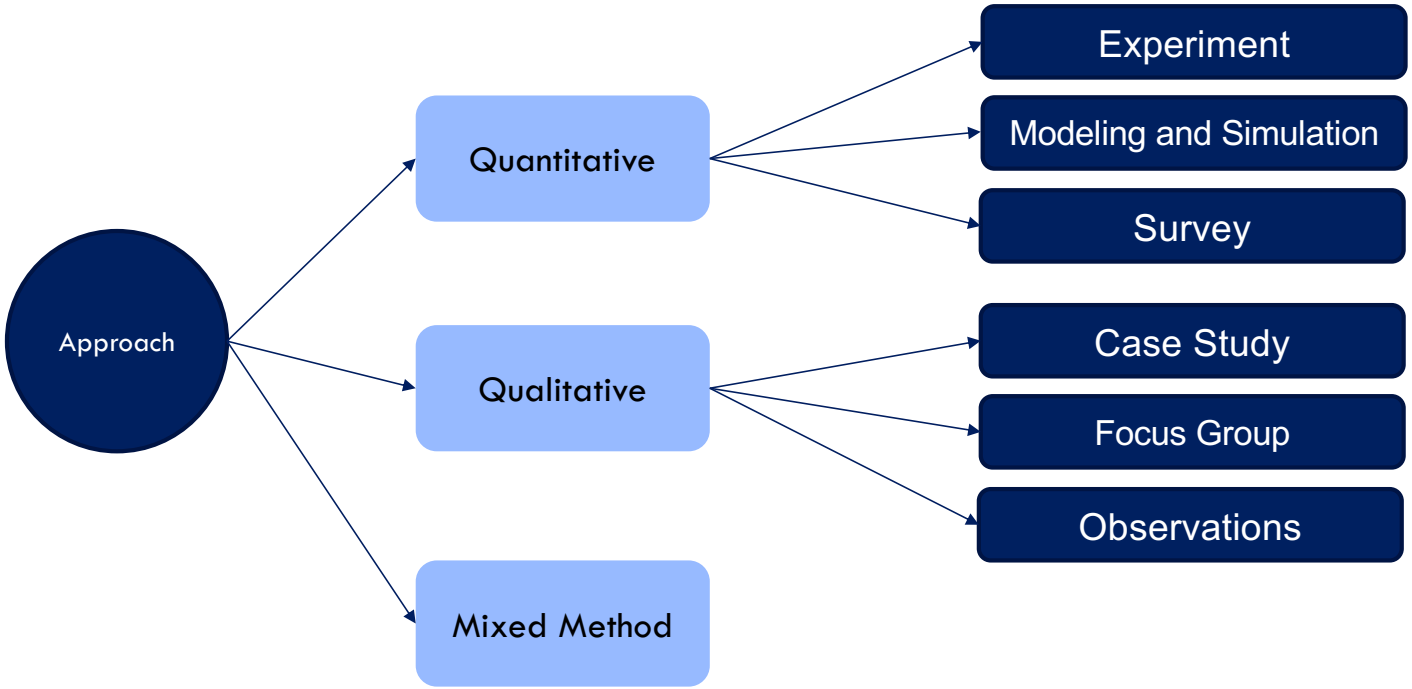
Research Perspective

- Field (Position of the research within a hierarchy of topics)
  - » Example:
  - » Artificial Intelligence → Automated Reasoning → First-Order Reasoning → Decidability
- Approach (Research methods that are employed as part of the research process)
  - » Examples:
  - » Case study, Experiment, Survey, Proof
- Nature (Pure theoretical development)
  - » Review of pure theory and evaluation of its applicability
  - » Applied research

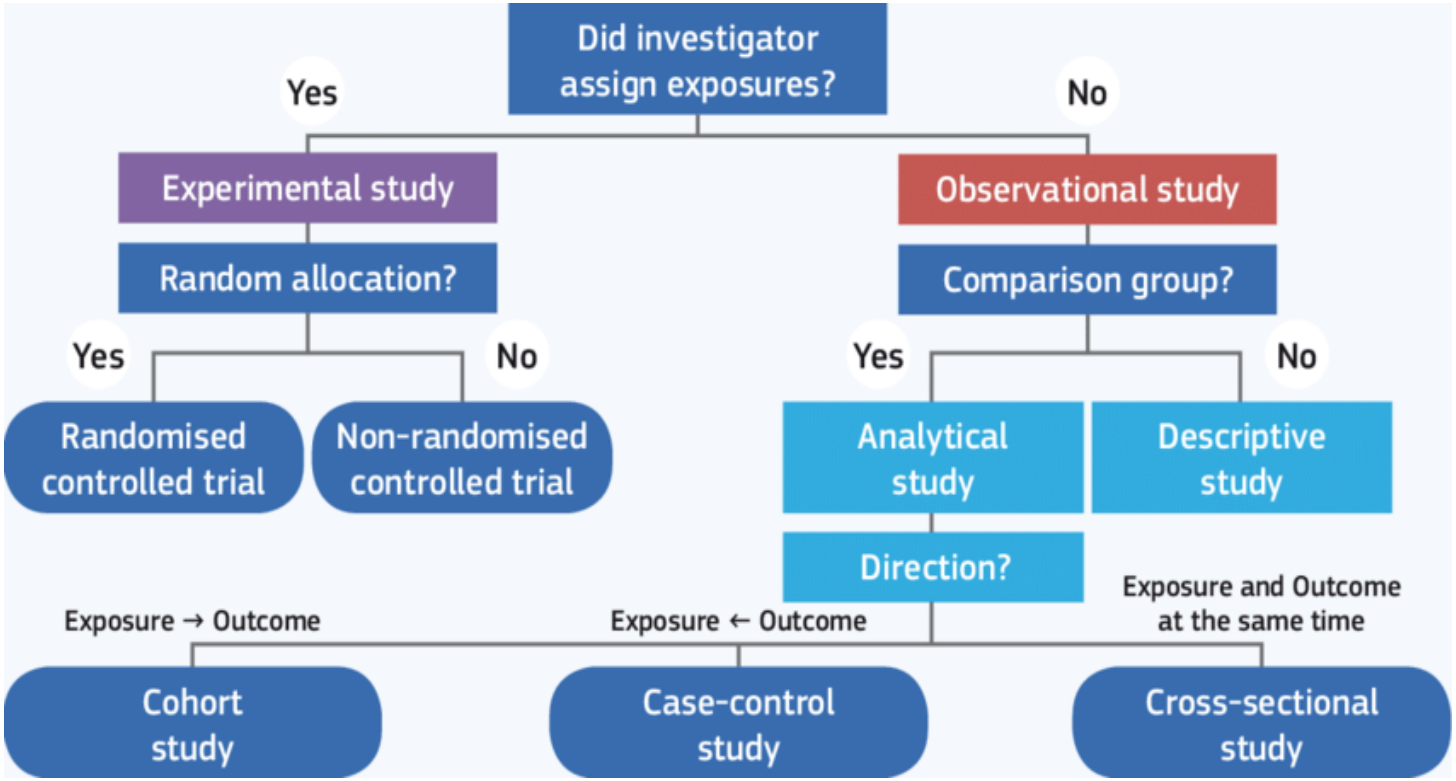
Classification of Scientific Research



Classification of Scientific Research



Example of Classification Research



Research Approach

- Quantitative research methods Method
  - » Associated with measurements (on numeric scales) Stemming from natural sciences
  - » Used to test hypotheses or create a set of observations for inductive reasoning
  - » Accuracy and repeatability of vital importance
- Qualitative research Methods
  - » Methods involving case studies and surveys Stemming from social sciences
  - » Concerne with increasing understanding of an are, rather than an explanation
  - » Repeatability usually a problem

Research Methods

- Action research:
  - » Pursues action (or change) and understanding at the same time
  - » Continuously alternates between action and critical reflection, while refining methods, data and interpretation in the light of the understanding developed in the earlier cycles
  - » Example: Reflective teaching
- Case study:
  - » In-depth exploration of a single situation
  - » Usually generates a large amount of (subjective) data
  - » Should not merely report the data obtained or behaviour observed but attempt to generalise from the specific details of the situation observed
  - » Example: Case study of open source software development

Research Methods

- Survey:
  - » Usually undertaken using questionnaires or interviews
  - » Questionnaire and interview design important!
  - » Determination of sample size and sample elements important!
  - » Example: Survey on the popularity or use of programming languages
- Experiment:
  - » Investigation of causal relationships using test controlled by the researcher
  - » Usually performed in development, evaluation and problem solving projects
  - » Example: Evaluation of processor performance

Research Paradigm in Computer Science

- Empirical:
  - » Computer science is concerned with the study of a class of phenomena
- Mathematical:
  - » Computer Science is concerned with the study of algorithms and properties of information structures (abstraction from real objects)
- Engineering:
  - » managing the cost-effective design and construction of complex software-hardware systems (commercially and socially valuable)

Experimental Techniques

- Depending on the objective, various evaluation techniques shall be used
  - » Quantitative testing/experiments of algorithms/programs/databases/...
  - » Usability tests with users
  - » Questionnaires
  - » Surveys
  - » Case studies

So, in order to experiment we need Data set

- Real-world data
  - » Always good to have – show that system works in practice
  - » Sometimes difficult to obtain
  - » Do not allow to test all aspects of an algorithm/system
- Synthetic data
  - » Allow to test specific aspects of the algorithm
  - » Often (very) difficult to generate
  - » If possible, try to use the same data as your competitors
- It is easy to show that your approach is better if only very particular data is used
- Describe the most important aspects of the data

After experiment, compare the solution (Benchmarks)

- Use existing benchmarks as much as possible
- Facilitates the comparison of different solutions

Quantitative Research

Introduction

- Emphasizes on objective *measurements*
- Emphasizes on *statistical, mathematical or numerical analysis* of data
- It is a *systematic empirical investigation* of any phenomena via statistical, mathematical, or computational techniques
- Data are collected through polls, surveys, questionnaires, or by manipulating pre-existing statistical data using computational techniques.
- Presented in numerical form and analyzed through the use of statistics.

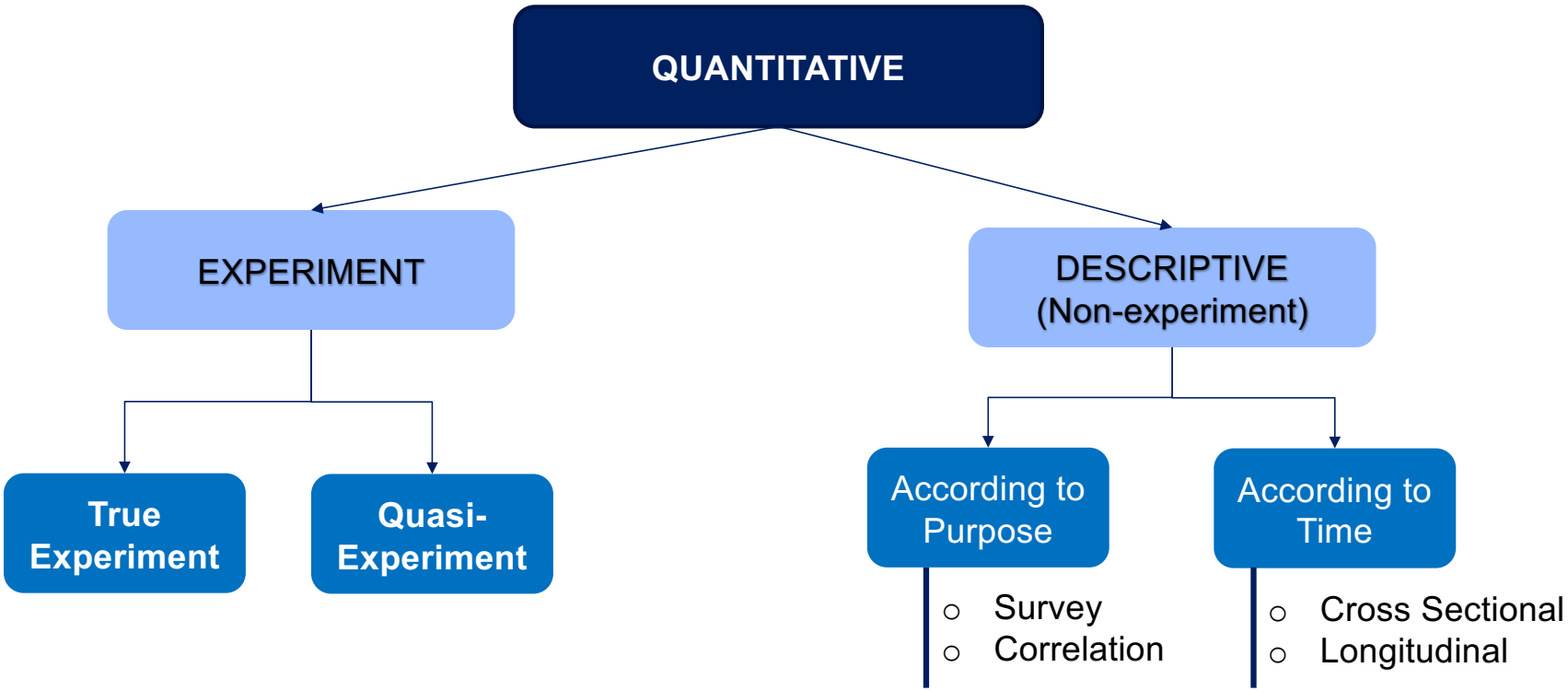
Characteristics of Quantitative Research

- Objective research.
- Data is gathered using STRUCTURED research instruments.
- Results are based on larger sample sizes.
- Can be replicated or repeated, given its high reliability.
- Has a CLEARLY defined research question.

Characteristics of Quantitative Research

- All aspects of the study are CAREFULLY designed.
- Data are in the form of numbers and statistics, often arranged in tables, charts, figures, or other non-textual forms.
- Project can be used to generalize concepts more widely, predict future results, or investigate causal relationships.
- Researcher uses tools, such as questionnaires or computer software, to collect numerical data.

Type of Quantitative Research

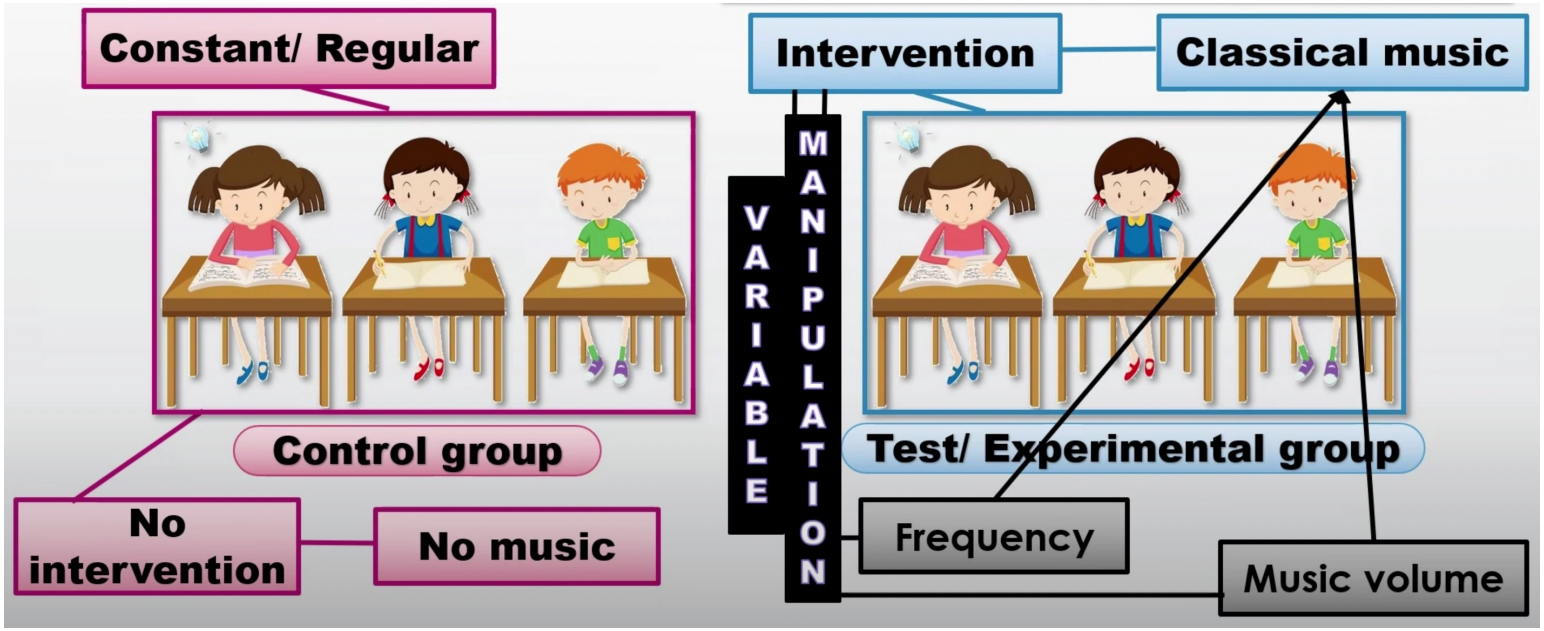


(1)(a) True Experimental Research

- Often called **TRUE experimentation**, uses the scientific method to establish the cause-effect relationship among a group of variables that make up a study.
- Variable manipulation
- Random selection of participants.
- The true experiment is often thought of as a laboratory study (controlled setting).
- Involves a control group and a test group.
- Relies on statistical analysis to approve or disapprove a hypothesis.
- Consider as the **most accurate** type of experimental design.

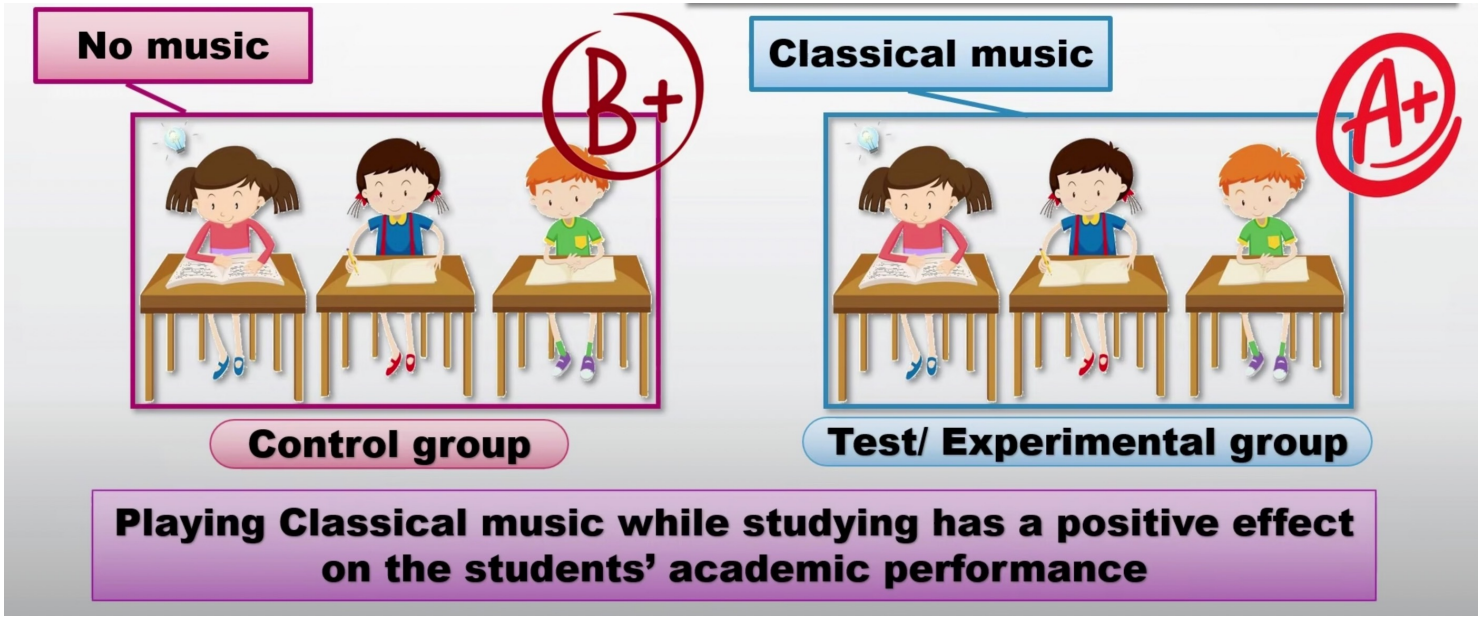
(1)(a) True Experimental Research: Example 1

Study the effect of classical music on academic performance of students



(1)(a) True Experimental Research: Example 1

Study the effect of classical music on academic performance of students



(1)(a) True Experimental Research: Example 2

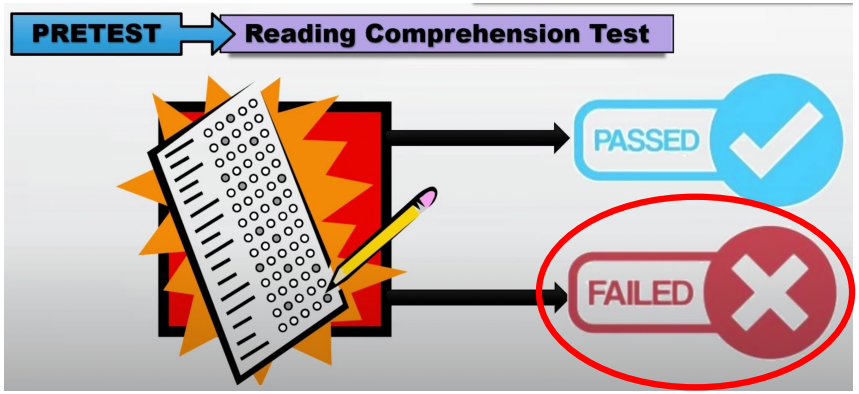
- Study the effect of junk food on obese people.
- Assign some participants in the treatment group where they are fed only junk food. While the other half of the participants go to the control group, where they have their regular ongoing diet (standard course).
  - » Take obese people's reports every day after their meals to note down their health and discomfort if any.
- Although, participants who are assigned to the treatment group would not like to change their diet to complete junk food for personal reasons.
  - » In this case, you cannot conduct a true experiment against their will. This is when quasi-experiment comes in.

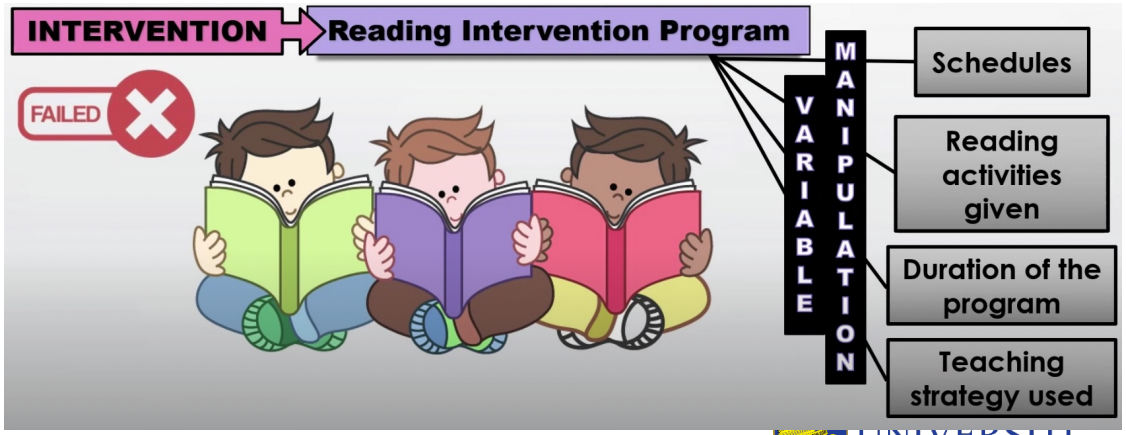
(1)(b) Quasi-Experimental Research

- To establish cause-effect relationships among the variables (independent and dependent variables).
- These types of design are very similar to true experiments, but with some key differences.
- An independent variable is identified but not manipulated by the experimenter, and effects of the independent variable on the dependent variable are measured.
- Quasi-experiments do not include random assignments of participants. Meaning, the participants are placed in the experimental groups based on some of the other criteria.

(1)(b) Quasi-Experimental Research: Example 1

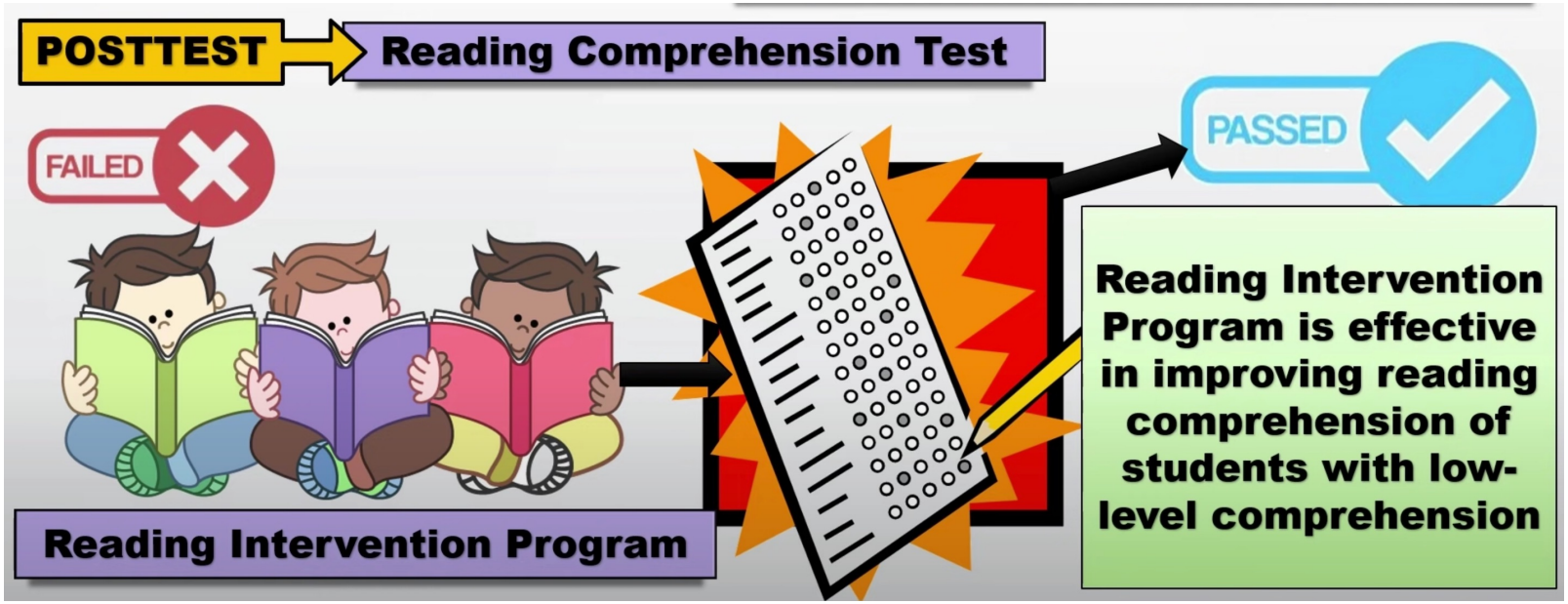
Reading Intervention programme as aid for students with low level comprehension





(1)(b) Quasi-Experimental Research – Example 1

Reading Intervention programme as aid for students with low level comprehension

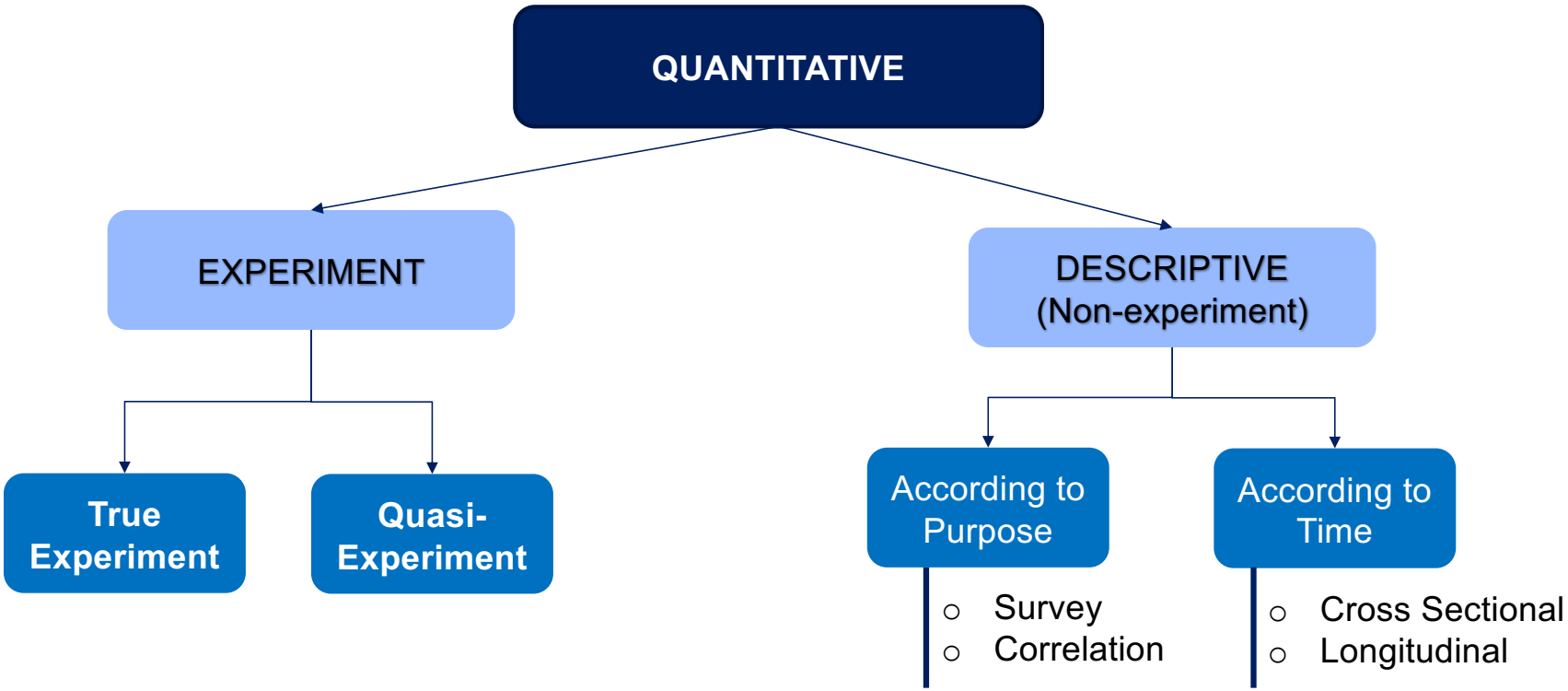


(1)(b) Quasi-Experimental Research – Example 2

- Assessing the effectiveness of a public health campaign: In this study, a public health campaign is launched to promote healthy eating habits among a targeted population. The behavior of the population is compared before and after the campaign to determine whether the intervention had a significant impact on the target behavior.
- Assessing the impact of a new policy: In this study, a new policy is implemented in a particular area, while another area does not have the new policy. The outcomes of both areas are compared before and after the intervention to determine whether the new policy had a significant impact on the targeted behavior or outcome.

To be continued

Type of Quantitative Research



(2) Descriptive (Non Experimental) Research

- Descriptive research also known as non-experimental research.
- Seeks to describe the current status of an identified variable. These research projects are designed to provide systematic information about a phenomenon.
- The researcher does not usually begin with an hypothesis, but is likely to develop one after collecting data. The analysis and synthesis of the data provide the test of the hypothesis.
  - » the intention is to only establish **ASSOCIATIONS** between variables; and
  - » the study may include a sample population of **hundreds** or **thousands** of subjects.

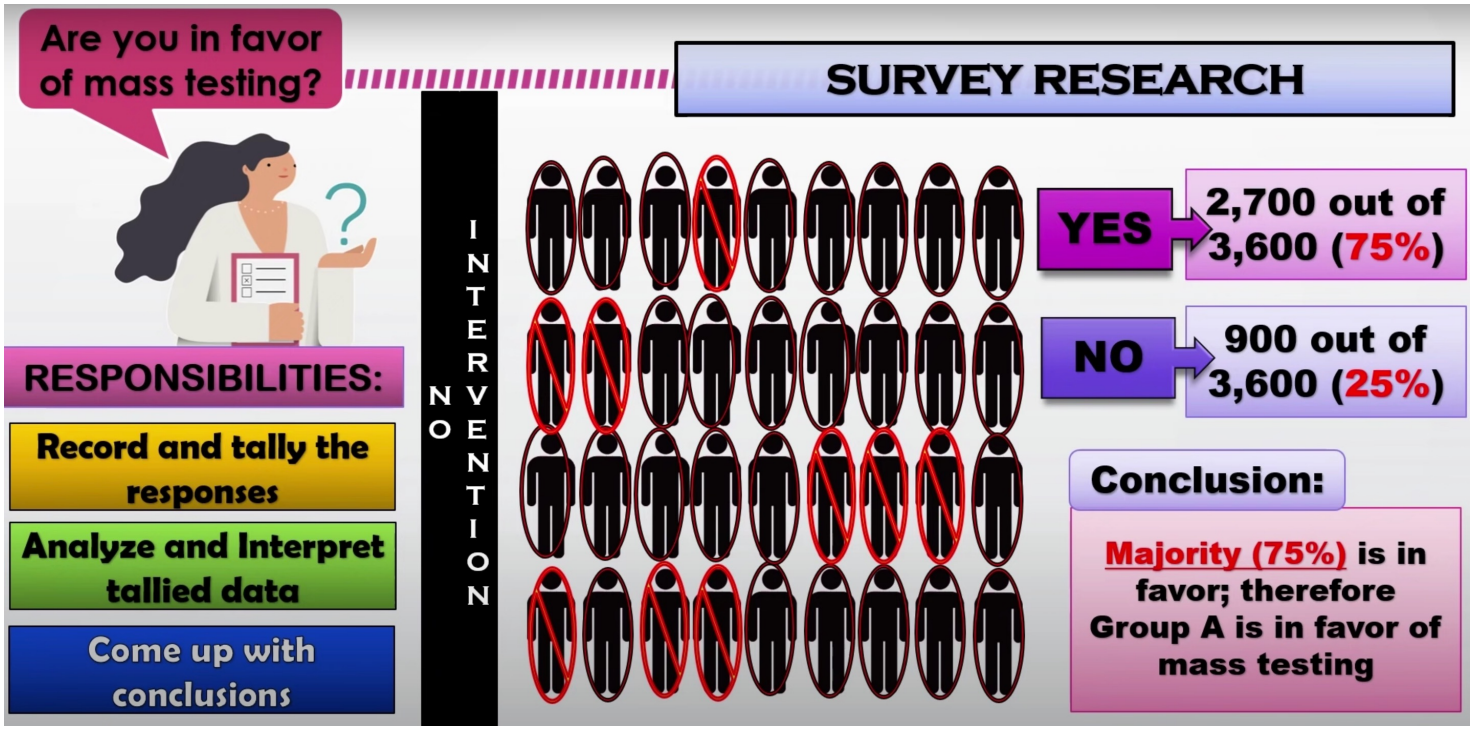
(2) Descriptive Research: Examples

- ✓ An academic institution may wish 2 compare the performance of its junior high school students in English language and Mathematics. This may be used to classify students based on 2 major groups, with one group going ahead to study while courses, while the other study courses in the Arts & Humanities field.
- ✓ Students who are more proficient in mathematics will be encouraged to go into STEM and vice versa. Institutions may also use this data to identify student's weak points and work on ways to assist them.

(2)(a) Descriptive Research: Purpose - Survey

- To gather evidence on people's knowledge, opinions, attitudes and values on various issues and concerns.
- Makes use of questionnaire, interviews and surveys.
- Variables are not controlled or manipulated.
- No intervention is applied.

(2)(a) Descriptive Research: Purpose - Survey (Example 1)



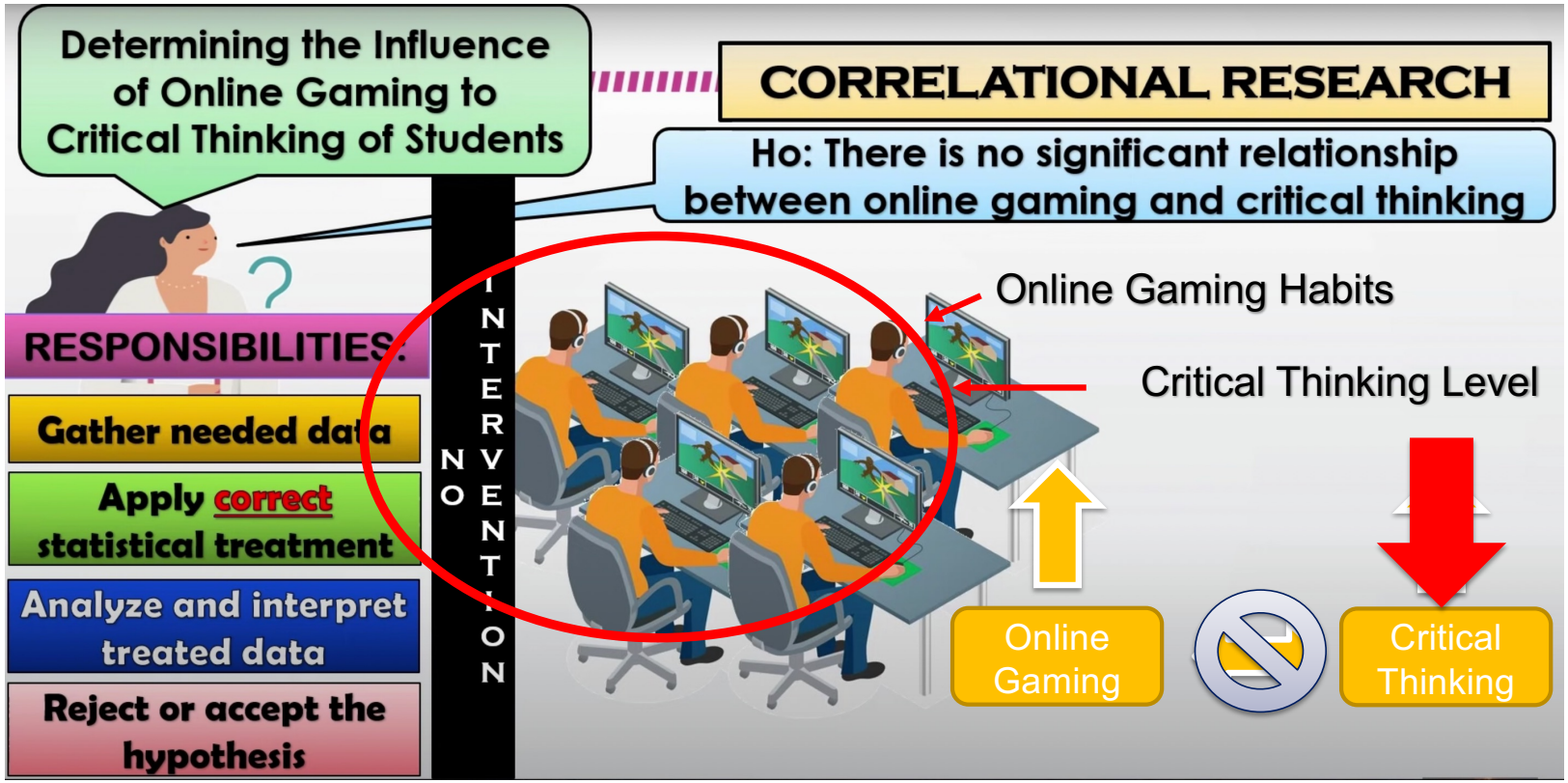
(2)(a) Descriptive Research: Purpose - Survey (Example 2)

- An organization may study how people with different income levels react to the launch of a new Apple phone.
- This kind of research may take a survey that will help determine which group of individuals are purchasing the new Apple phone. Do the low-income earners also purchase the phone, or only the high-income earners do?
- Further research using another technique will explain why low-income earners are purchasing the phone even though they can barely afford it. This will help inform strategies that will lure other low-income earners and increase company sales.

(2)(b) Correlation Research

- To determine the extent of a relationship between two or more variables using statistical data.
- This type of research will recognize trends and patterns in data, but do not aim to determine cause and effect relationships.
- It aims to find whether there is; positive correlation (both variables change in the same direction), negative correlation (the variables change in the opposite direction), or zero correlation (there is no relationship between the variables).

(2)(b) Correlation Research: Example

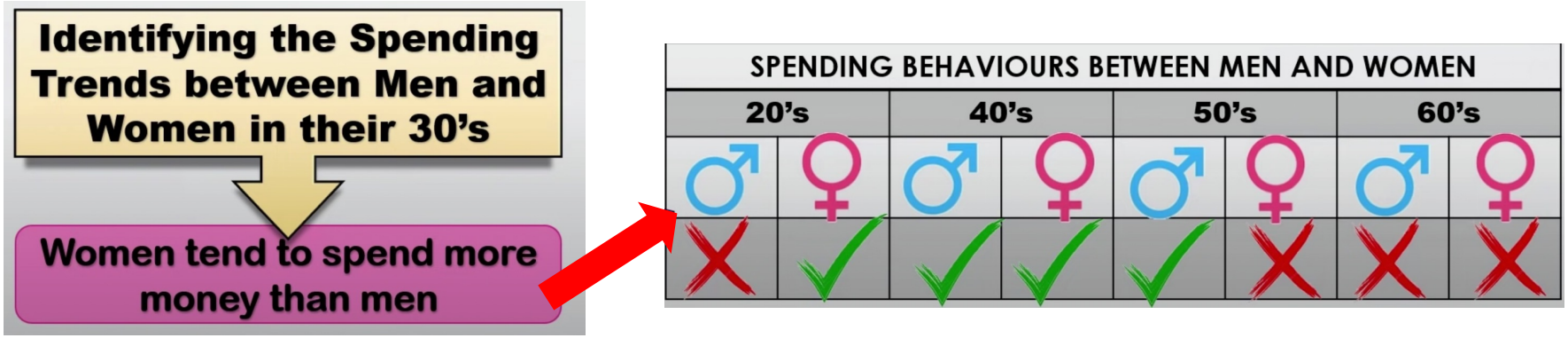


(2)(b) Correlation Research: Example

- A researcher is studying a correlation between cancer and marriage. In this study, there are two variables: disease and marriage. Let us say marriage has a negative association with cancer. This means that married people are less likely to develop cancer.
- However, this doesn't necessarily mean that marriage directly avoids cancer. In correlational research, it is not possible to establish the fact, what causes what. It is a misconception that a correlational study involves two quantitative variables. However, the reality is two variables are measured, but neither is changed. This is true independent of whether the variables are quantitative or categorical

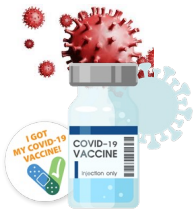
(2)(c) Cross Sectional Research (Time)

- Involves gathering data at a **single point** in time.
- Focuses on same set of variables.
- Comparisons are made across variable of interests



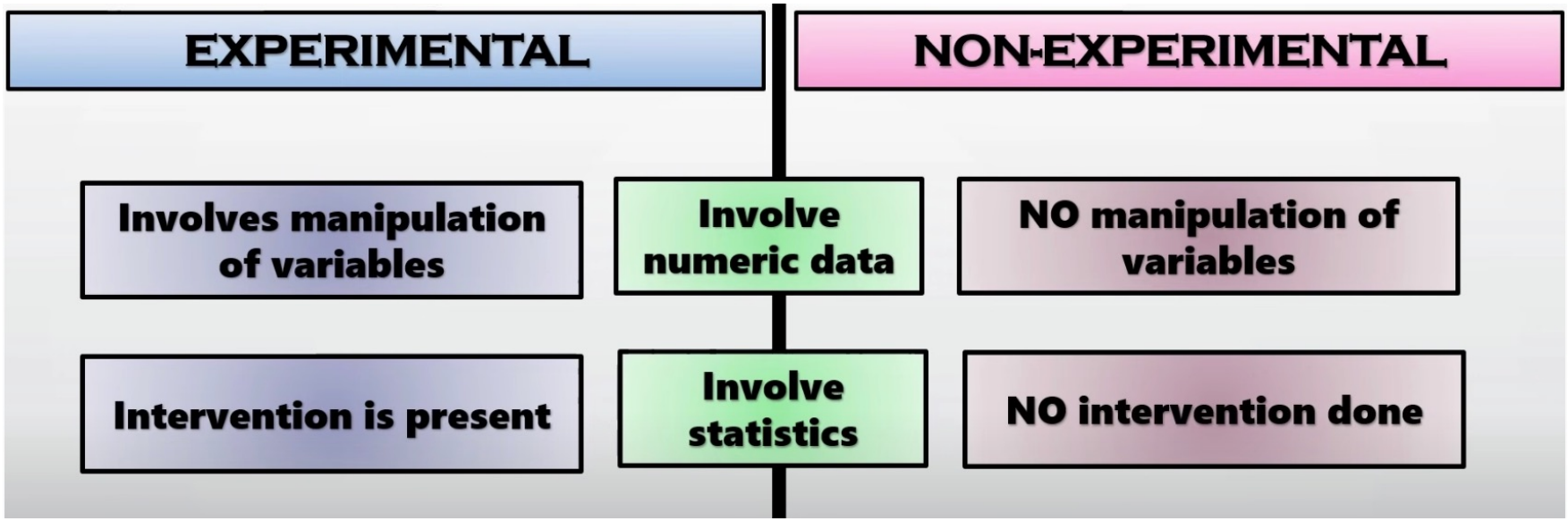
(2)(d) Longitudinal Research (Time)

- Involves gathering data at a **multiple** point in time.
- Collects data from **present** and **again** in the **future**.
- Done for the purpose of comparing data sets.
- Examples: Covid-19 vaccination



1st month	4th month	10th month	16th month	22nd month	28th month
1,500	1,000	700	300	100	0

Experimental vs Non-Experimental Research



Strength of Quantitative Research

- Allows for a ***BROADER STUDY***.
  - » involving a greater number of subjects; and
  - » enhancing the generalization of the results.
- Applying ***WELL ESTABLISHED STANDARDS***
  - » the research can be *replicated*, and then *analyzed* and *compared* with similar studies;
- Allows for ***GREATER OBJECTIVITY*** and ***ACCURACY*** of results.
  - » provides summaries of data that support generalizations about the phenomenon under study
  - » involves few variables and many cases
  - » employs prescribed procedures to ensure validity and reliability

Weakness of Quantitative Research

- Uses a static approach and so employs an **inflexible process of discovery**.
- The development of standard questions by researchers can lead to **"structural bias"** and **false representation**, where the data actually reflects the view of the researcher instead of the participating subject.
- Results provide **less detail** on behavior, attitudes, and motivation.
- Researcher may collect a much **narrower** and sometimes **superficial dataset**.
- The research is often carried out in an unnatural, artificial environment so that a level of control can be applied to the exercise. This level of control might not normally be in place in the real world thus yielding **"laboratory results"** as opposed to "real world results".
- **Results are limited** as they provide numerical descriptions rather than detailed narrative and generally **provide less elaborate accounts of human perception**.

Thank You

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