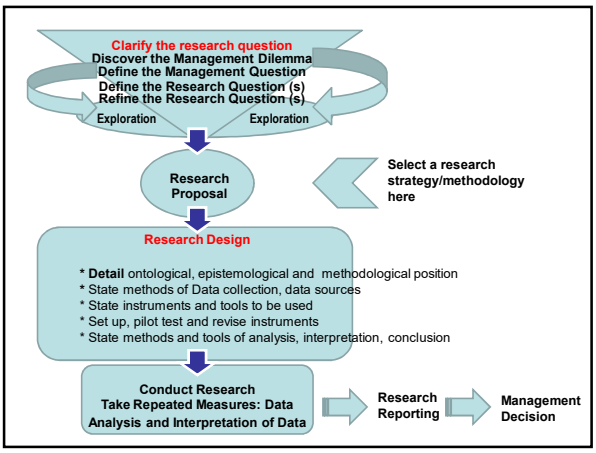
Research Methodology

Lecture 10:
Experiment



Research Strategies

- Various Research Strategies
  - Interpretive-Historical Research
    - Archival Studies
  - Qualitative Research
    - **Grounded Theory, Ethnography, Interpretivism and Phenomenology**
  - Co-relational Research
    - **Survey Research**
  - Experimental and Quasi-experimental Research
    - **Causal Relation**
  - Simulation and Modeling Research
  - Case Studies

Definition

- What is experiment?
  - Objective observation
  - Of phenomenon that is made to occur
  - In a strictly controlled situation,
  - Where one or more factors are varied and the others are kept constant
- Independent variable (IV), dependent variable (DV), confounding variable
  - IV is the variable that is manipulated

Definition

- What is experimentation?
  - manipulating the independent or explanatory variable and then
  - observing whether the hypothesized dependent variable is affected by the intervention
  - there should be at least one independent variable and one dependent variable
  - in a causal relationship

Experimental Research

- **Experiments: settings for observation of an artificially produced phenomena or interaction**
  - For identification of the necessary and sufficient conditions for the occurrence of an event
  - Experiments use conscious and deliberate control of environment/context

Goals and Objectives

- Goal of an Experiment is to discover the effects of presumed causes
- Experiments are methods of
  - Discovering causal connections
  - Testing hypotheses or propositions
  - Ways of demonstrating proof of a phenomenon
    - All phenomena taken as a network of cause-and-effect relations

Causation

- Cause – variable that starts off a phenomenon - contextually dependent
- Effect-the difference between what would have happened (without the cause variable) and what did happen (with the cause variable)
- Experiments may be repeated to make a series of observations to establish a causal relationship

Law of Causation

- Law of causation is a special form of the Law of Uniformity of Nature.
  - Every phenomenon has a cause and the same cause always gives rise to the same effect.
  - The cause is an invariable antecedent and the effect an invariable consequent of cause.
    - Cause has a temporal precedence over effect.

To summarise,

- Experimental research tests causal relationships in a controlled environment > aims to determine or predict what may occur
- Is manipulation of independent variable, holding all other variables except dependent variable constant to observe effect of manipulation of independent variable on dependent variable
- Depending upon field of enquiry, nature of manipulation, control and observations may differ and controls may be total, selective or statistical.

Experimental Design

- Two fundamental considerations of experimental design are:
- That the independent variable is the only factor that varies systematically in the experiment; in other words, that the experiment is appropriately controlled - that the confounding variables are eliminated; and
- That the dependent variable truly reflects the phenomenon under study and that the variable can be measured accurately (i.e., that various types of experimental error, such as measurement error can be eliminated).

Experimental Design

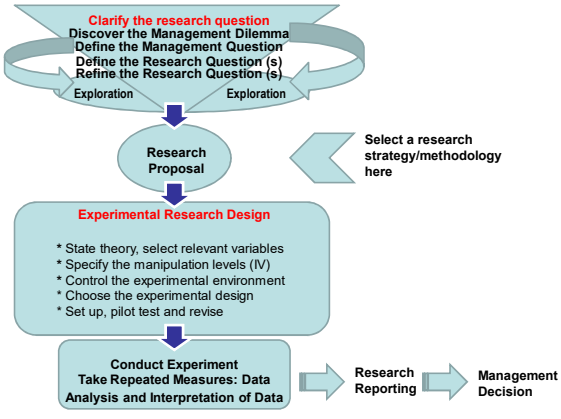
- The design of experiments attempts to balance the requirements and limitations of the field of science in which one works so that the experiment provides the best measure and conclusion. The requirement of objective control and measurement of experiments is met differently by different sciences:
  - Physics and Chemistry
  - Biology and Medicine
  - Social studies

Experimental Design

- Experiments are done
  - In Laboratory or field for Natural Sciences
  - In Field for Social Sciences
  - Most rigorous from internal validity considerations
  - Experiments assess change propositions or hypothesis
- **If x then y type of proposition**
  Acid + Base = Salt + Water
  HCl + NaOH= NaCl+H_2O (Neutralization reaction)
- **Important to 'control' other 'variables' and the 'environment' or context**
  - If plants get sun-light, their leaves turn green!
  - The rate at which grass grows is not dependent on the amount of light it receives.

Experiment in Laboratories: Control and Manipulation

- 'control' of other 'variables' or the 'environment'
  - Variables in the experiment, independent variable (IV) that is manipulated and dependent variable (DV), changes are observed in it
  - **Multiple independent variables**: separate experiment for each variable
    - Plant Growth and air, water, nutrient, light & type of soil
- Experiments must have a hypothesis or theory
  - Wearing of mhp turbines due to head and sediment load, shape of particles, material and design of blades
  - Iron impregnated activated carbon are very effective adsorbent of arsenic in water, texture of Lupsi-seeds suggest its potential for making activated carbon for arsenic filter



Making Experiment in Laboratories

- Design your research
- Write your theory
  - For experiment, observation and analysis
- Show equations/model to explain the expected change
- Design the experimental equipment and setup
  - Assess possible errors and make corrections.
- Define control conditions
- Materials required/sample for tests etc
- Make/Take pretest/posttest observations/measures

Advantages of the experiment

- Causal inference
  - Causal description
  - Causal explanation
- Control – control of contamination from extraneous variables more effectively
- Ability to manipulate variable – independent variable
  - Convenience and costs as compared to search for fortuitous experience
- Replication

Disadvantages of the experiment

- Does not test effect of non-manipulated variables—constituent variables in the environment, context (age, weather, etc.)
- Artificiality
- The phenomenon must be replicable for this strategy to be usable
- Study of the past not feasible
- Ethical issues in manipulation and control

Research Methodology

Lecture 10.2:
Experiments and Quasi-experiments in Social Studies

Research Strategy – Experiment in Social Studies

- Essence of 'scientific research' (positivist/post-positivist paradigm)
- Often portrayed as the standard against which other research strategies are judged
  - No experiments in Constructivist and Emancipatory (critical theory/post-modern) paradigms

Key Characteristics

- A focus on causality
- The use of a treatment, or independent variable
- A clear unit of assignment (onto which the treatment is applied or the phenomenon unit/context)
- The measurement of outcome, or dependent variable/s
- The use of a comparison unit (or control set up)
- Temporal arrangement: cross-sectional and longitudinal settings

Experimental Research

- **Depending upon field of enquiry, nature of treatment, intervention or manipulation, 'control' and observations may differ.**
- Ethics and practicality of social experiments.
- Can/should one manipulate human circumstance?
- Human response is **intentional**, **reactive** and can be **calculated**!
  - Design of controls and contexts so that such responses are to be dealt with

Experimental Research

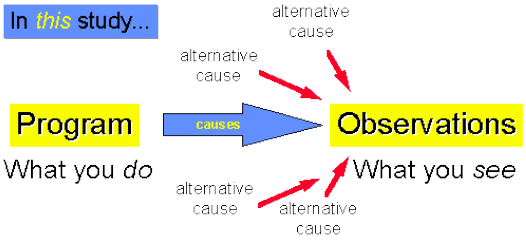
- **Design of experiment consists of**
  - **selection of environment (sample of subject) or medium for inputs/treatment and measuring outcomes or corresponding elements in cause and effect predictions.**
  - **selection of groups or pairs of subjects or interacting elements**
  - **identification and control non-experimental factors**
  - **select and construct and validate instruments to measure outcomes**
  - **(pilot tests)**
  - **determination of place, time and duration of experiment**

Causation

- Cause
  - contextually dependent
- Effect-the difference between what would and what did happen
- Causal relationship-what evidence is needed?
  - Internal Validity
- Primary Consideration in any causal design
  - Internal validity is the approximate truth about inferences regarding the causal relationships

Validity: External Validity, Construct Validity, Internal Validity

Possible Threats to Internal Validity: alternative explanations "Third Variable"



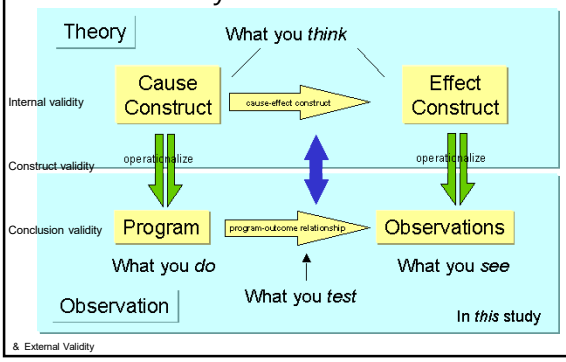
Establishing Cause & Effect

- **Establishing internal validity means confirming the cause- effect relationship**
  - **Proper design of the 'experiment' research** can overcome many of the threats to internal validity
  - The best assurance of internal validity can be had through design where program group is compared with a comparison or control group
  - Equivalent Group > probabilistic equivalence

Establishing Internal validity

- Criteria for establishing a causal relation
  - Temporal precedence
    - **Cause (program) happened before effect (outcome)**
  - Co-variation of cause and effect
    - **If program, then outcome**
    - **If no program, then no outcome**
    - **If more of a program, then more of the outcome**
    - **If less of a program, then less of the outcome**
  - No plausible alternate explanation
    - **The outcome observed could not have resulted from other non-program factors or events**

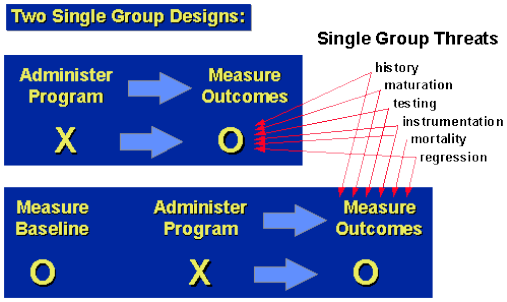
Quality of Research: Example Validity in Causal Studies



Validity

- Validity of research findings > reasonable construct of relations
- Reasonableness at different levels
  - Internal validity: accuracy of causality assumed in cause-effect construct: Theory for the experiment
  - Conclusion Validity: accuracy of program-outcome construct: Valid outcomes
  - Construct validity: correctness of operationalization (inter-relation of cause-effect and program-outcome construct): validity of the experimental setup
  - External validity: appropriateness of generalization.

Single Group Experiments
and Threats to Internal validity



Threats to Internal Validity:
plausible alternative explanations in single group

- History threat: when specific historical event other than program affects outcome
- Maturation threat: performance affected by normal maturation or growth of group during the period
- Testing threat: occurs when taking the pretest affects how participants do on the posttest
- Instrument threat: occurs when the test instrument or observers used on the posttest and the pretest differ
- Mortality threat: significant participant drop out
- Regression threat: non-random studies have this particularly if extreme group predominate and they can only improve/not fall further down

Threats to Internal Validity:
plausible alternative explanations in single group

- Way to overcome: study two or more groups
- Treatment group and Control group or Comparison group
- Crucial assumption: The groups are comparable in all respects!
- Multiple group threats are called Selection bias or selection threat
- Selection-history threat, selection-maturation threat, selection-testing threat, selection-mortality threat, selection-regression threat
- Random assignment in groups – making true experiments with multiple groups – solves these threats
  - Social threats would still be there

Social Interaction Threat

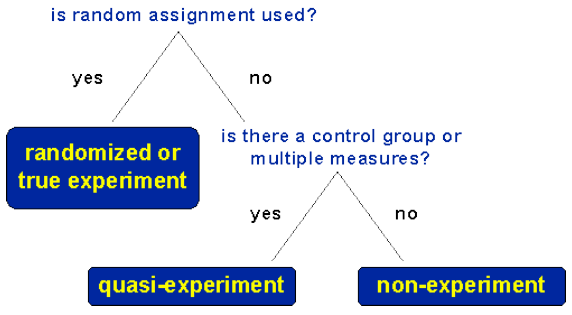
- Diffusion or Imitation of treatment
- Compensatory rivalry
- Resentful demoralization
- Compensatory equalization of Treatment

[Two groups experimental design/ Program group – Comparison group]

Types of Experiment Design

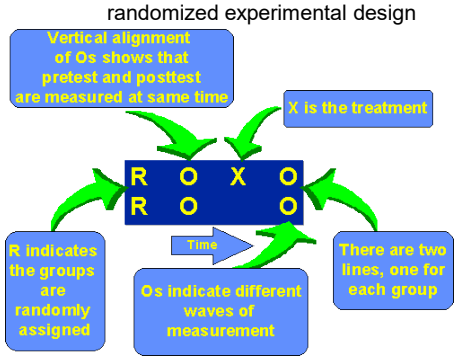
- **Field/Social Science experiments**
  - with a few of several variables/ condition/field or environment controlled.
  - Certainty/ replicability put in probability term
  - randomized experiments are taken as true experiments
  - others use multiple waves of measurements or multiple groups for comparative study: quasi-experiments (i.e., not as true as randomized ones but still nearing it in essence)
  - those which are neither randomized nor provide for multiple observations are non-experiments.

Types of Designs (E,Q-E & N-E)



Design Notations (E,Q-E & N-E)

*pretest-posttest treatment versus comparison group randomized experimental design



Posttest Only Randomized Experiment	R X O R O
Pretest-Posttest Nonequivalent Groups Quasi-Experiment	N O X O N O O
Posttest Only Non-Experiment	X O

Simplest randomized experiment is Two-group, posttest-only randomized experiment.

R Random assignment

- Random assignment – How you assign the sample you draw to different groups in your study
  - Say have a treatment group and a control group
  - Need to decide whether an individual should be placed in treatment group or control group
  - Decide by flipping a coin so that individual is assigned to treatment if heads and control if tails
  - Helps to strengthen Internal validity
  - **Two groups are probabilistically equivalent**
  - Randomized or True Experiment
- Random sampling (sample from a population)
  - Helps to strengthen External validity

Probabilistic Equivalence

- Random selection > sample from population > external validity
- Random assignment > sample to groups or treatments > internal validity
- Statistical significance = α =0.05
  - Groups made using random assignment are probabilistically equivalent (no human being or group is perfectly equivalent) > In physical experiments, portions of any sample are perfectly equivalent!
  - Only 5 out of 100 times that the difference observed between the two groups can be due to chance or **95 times out of 100, the observed difference between the two groups is due to the treatment (significant difference as opposed to chance difference)**

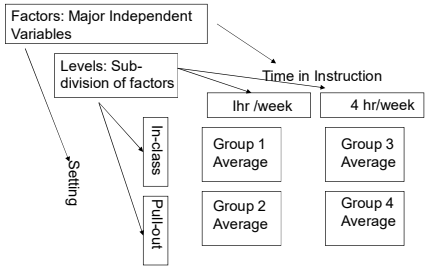
Factor/Block Design: Reducing Noise

- Factor Design
- If you want to do a experiment with more than one independent variable, then factorial design needs to be followed
- Block Design
- Implementing the experimental treatment (all possible permutations of IVs) in a number of randomly assigned blocks

True-Experiment, equivalent groups Quasi-Experiment, non-equivalent groups

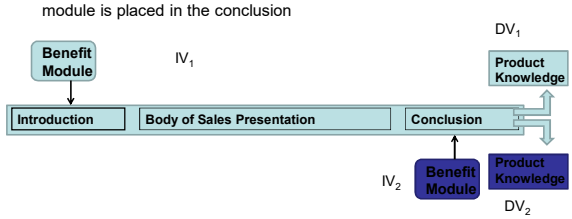
- Theory: Students show higher achievement if they are given a longer period of instruction and also if the instruction is given in a pull-out setting than in in-class setting
- In-class (2 groups/random assigned) and pull-out (2 groups of smaller numbers, random assignment) (IV1), one in each group given instructions of 1 hour and 4 hours each (IV2)
- Measurement and comparision of learning outcomes (DV)

2X2 Example



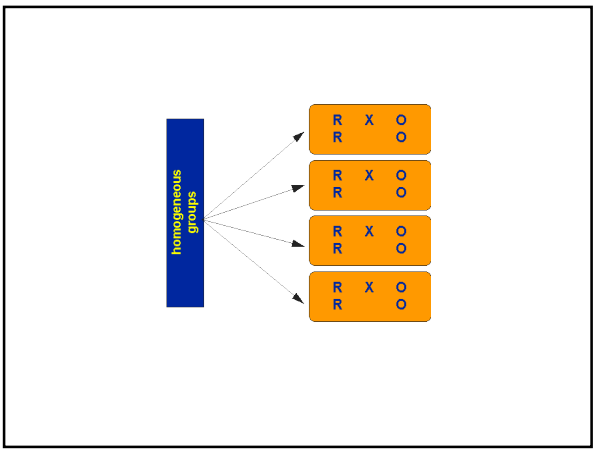
Experiment of Placement of Benefits Module within Sales Presentation

Hypothesis: Sales presentations in which the benefits module is placed in the introduction of a 12-minute message produce better retention of product knowledge by the customer than those where the benefits module is placed in the conclusion



Managing Extraneous Variables

- Controlling the experimental environment - consistency
  - Age, gender, race, dress, communication competence
  - presenter
  - Message
  - Situation, physical environment, room arrangement, time of presentation
- Selecting Subjects
  - Random sample and random assignment
- Subjects – unaware of treatment, unaware control group or treatment group
  - Blind experiment
- Subjects and experimenters both unaware of experimentation
  - Double blind experiment


homogeneous groups
R R X O O
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