Developing Instruments for Scientific Research: Implications for Analysis

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Scientific Research- What is it?

- Research can be defined as the process of arriving at dependable solutions to a given problem.

- Research is about knowing - The acquisition of data, knowledge and information.

- There are several ways that we can obtain knowledge.
  - Tenacity - The drive to hold firmly to something you believe to be true, just because you have always believed it.
  - Personal experience
  - Tradition /Authority (Church, State and Ancient Scholars)
  - Expert Opinion
  - Apriori Methods - Deductive and inductive Reasoning

Scientific Research

- Do not accept a statement as true even though the evidence at first looks promising.

- In science we are talking about Objectivity, control of bias, verification, assuring validity and reliability.

- Research can be defined as the process of arriving at dependable solutions to a given problem through planned and systematic collection, analysis and interpretation of data (Gay, 1992)

Scientific Research

The scientific method summarized as:

- Identification and definition of the problem

- Formulation of hypothesis or Research Questions

- Collection, organization and analysis of data

- Formulation of conclusions

- Verification, rejection or modification of hypothesis by the test of its consequences in a specific situation. Or answering of research questions.

Note: Qualitative and Quantitative Research paradigms are scientific.

What is Research Instrument?

- One needs to design or use research instrument(s) to collect any data and analyze to solve the problem.

- A research instrument is the means/tool/device designed to measure variable(s), characteristic(s), or information of interest.

- Research instruments include questionnaires (tests, scales, ratings), interview schedule, checklist for FGD, and observations

Research Instrument

Focus Group discussion

- The discussion focuses on several open ended questions (Checklist) data on expectations, resources, programme design, strength of activities and learning outcomes etc.

Observations

- This is an instrument that is employed by a researcher in which an individual's behavior or situation is observed and recorded.

- Observations are made on Experimental/Quantitative and Descriptive/Qualitative methods of enquiry

Research Instrument.......Cont'd

Interviewing

- The technique involves oral questioning of respondents, either individually or as a group.

- Questions (Interview schedules) already prepared can be used during the interview session.

- Interview can build on questions asked as the session proceeds.

- Also known as oral questionnaire.

- The researcher poses questions to the respondents and the answers are recorded by the researcher using either tape recorder, paper and pen or pencil.

Research Instrument.......Cont'd

Questionnaires

- Self-administered questionnaire is probably the mostly used technique for data collection.

- The questionnaire can consists of a set of structured and unstructured questions designed by researchers to obtain data from the respondents.

Examinations

- Used when a researcher is interested in participants' knowledge

- Examination is better than asking respondents to accurately self-report on their knowledge because they do not know their level of knowledge, or they might not want to appear ignorant and therefore will bias their responses.

Table 1: Types of Research and examples of instruments

Type of Research	Instrument
Applied	Questionnaire, Interview and observation.
Survey	Questionnaire, focus group discussion, interview and observation.
Case study	Questionnaire, interview, focus group discussion and observation.
Ethnographic e.g. correlational research	Observation, questionnaire, focus group discussion and interview
Historical	Observation, focus group discussion and interview
Evaluation	Focu group s discussion, interview and observation
Experimental	Experiment and observation
Action	Observations, Questionnaire and interview
Longitudinal	Questionnaire, observation, focus group discussion, interview and experiment in case of pure science research.
Exploratory	Questionnaire, observation and interview.

Developing Instruments…..

- There are already developed instruments
  - Search for relevant questions that might have already been developed by the investigators and related to your objectives.
  - Adopt if suitable to your objectives
  - Or use as guide in construction of the new instrument.

Measurement of Variables using instruments

- Measurement is the process of assigning numbers to phenomena (data) according to some set of rules in a meaningful way so that the numbers represent the phenomena (data) and preserve certain empirical relationships which exist among the phenomena (data) being measured.

Developing Instruments......

- Variable is a term used to describe something that can be measured and can also vary.

- It is a characteristic that takes on different values for different individuals, places, or things.

- In other words it is a characteristic of a group of objects or events that can be measured over a number of different numerical values.

- Examples are age, sex, height, weight, length, breadth, time, speed, volume, income, IQ, grade, marital status, religion affiliation, district, and colour.

- The opposite of a variable is a constant. A constant is a quantity that doesn't change within a specific context.

Variables defined

- Variables can be straightforward and easy to measure, such as sex, age, or course of study.

- Other variables are more complex (e.g construct). Example socioeconomic status, academic achievement, or attitude toward school.

- Constructs must be operationalized. The operational definition of a variable consists of a statement of specifically how the construct will be measured or implemented in the study.

- Example the socio-economic status is typically measured by a composite of an individual's level of income, occupation, and level of education.

Scales of Measurement

- These are Nominal, ordinal, interval and ratio

- Nominal level scale
  - The simplest, lowest and most primitive measurement.
  - Variables are measured by categories and cannot be arranged in an ordering scheme.
  - All entities of one category are considered equivalent.
  - Examples: Sex of farmers 1=male; 2 = female), religious affiliation (1=Christian, 2= Muslim , marital status (1=married. 2=Divorce, 3=separated, 4 single).
  - It is essentially qualitative and numbers stand for names but not order or value.

Ordinal level

- Variables may be arranged in some order of magnitude or rank, but differences between varible values cannot be determined or are meaningless.

- Variables are measured by producing categories or numbers which can be ranked or ordered.

- It is used to indicate relative positions, rank, order of person in relation to others.

- It does not allow for addition and subtraction.
    - Example: Position in exams or class (1st, 2nd, 3rd);
    - Quality of produce(1=poor, 2=good, 3= excellent);
    - Age (1=youngest, 2=young, 3=oldest).
    - Educational level (1=Primary,2= JHS, 3=SHS, 4= Tertiary).

Interval level scale

Variables are measured by producing numbers which have equal intervals.

- There is no true zero to the scale. If zero is used, It is set arbitrarily or done for convenience and does not mean the absence of condition being measured.

- Examples:
  - Temperature on the Fahrenheit scale; 32 °F (The temperature at which water freezes into ice), 212 °F (Boiling point of water),
  - The lower defining point, 0 °F - temperature of a solution of brine made from equal parts of ice and salt.
  - IQ of 105 and 125 means that the IQ 125 is 20 points higher than 105.

- Intervals may be added to or subtracted from by a constant without changing relationship between interval points. They cannot be multiplied or divided.

Ratio level scale

- Ratio includes all other attributes of other levels plus an option of true zero(o).

- The true zero is lowest number which indicates absence of variable in question.

- Examples: Income, heights, age in years, years of experience, weight in kg.

- It is important one measures the actual value when using the ratio scale.

Scale of Measurement

- Note that the same variable can be measured on different scales

- Examples Age
  - Age 10, Age 20   -   nominal
  - Older or younger-   ordinal
  - 10-20, 21-30, 31-40 etc   Interval
  - 10, 11, 12, 13, 14, 15   Ratio

Performance of student

  – Pass or fail; – ordinal
  – GPA   – interval
  – Actual marks in examination s ,i.e, 50%, 60%, 80%   -ratio

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- Analysis is the processes of organizing data for interpretation.

- Involves coding, categorization of open-ended questions, transcribing of qualitative data (interviews), editing and checking, preparation of tables for statistical analysis, testing and presentation.

- Statistics analysis refers to using a body of mathematical technique(s) (Statistics) to organize and interpret data.

Types of statistics and data required

- Parametric and Non parametric data/Statistics

- Parametric
  - Assumes normal or near normal distribution
  - Measured data
  - Applies to interval or ratio scale.

- Non parametric data
  - Distribution free (does not rely on assumption of normal distribution.
  - Data are counted or ranked
  - Apply to nominal or ordinal scale

Table 2: Scales and implications for analysis

Measure	Nominal	Ordinal	Interval and Ratio
Measures of association	Tetrachoric correlation	Spearman's rho	Pearson product-moment correlation
	Point biserial correlation	Kendall rank order correlation	
	Phi coefficient Cramer's V	Kendall partial rank correlation	

Table 2 Cont'd:

Measures of difference	Nominal	Ordinal	Interval and Ratio
	Chi-square	Mann-Whitney U test	T-test for two independent samples
	McNemar	Kruskal-Wallis	T-test for two related samples
	Cochran Q	Wilcoxon matched pairs	One-way ANOVA
	Binomial test	Friedman two-way analysis of variance Wald-Wolfowitz test Kolmogorov-Smirnov test	Tukey post hoc test Scheffe test
	Nominal	Ordinal	Interval and Ratio
Measures of linear relationship between independent and dependent variables		Ordinal regression analysis	Linear regression
Identifying underlying factors, Data reduction			Multiple regression Factor analysis

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- Descriptive statistics and Inferential Statistics

- Descriptive which deals with summarizing and describing numerical data of a particular group

- Inferential statistics that deals with generalization of the findings of study from a sample (a small population) to a large population

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Data	Descriptive statistics
Nominal	Frequency counts, proportion, percentages, ratio
Ordinal	Frequency counts, proportion, percentages, ratio, mean, median and mode,
Interval	Frequency counts, proportion, percentages, ratio, mean, median and mode, standard deviation, variance
Ratio	Frequency counts, proportion, percentages, ratio, mean, median and mode, standard deviation, variance

Items on the research Instruments

- Each question or item on the instrument must try to answer a specific question in the objectives so as not to ask unnecessary questions.

- Questions that appear on instruments especially questionnaires can be open ended or closed questions.

- Open-ended questions

  o Permit free responses that should be recorded in the respondent's own words.

  o They could be facts, which the researcher is not familiar with, opinions, attitude, suggestions or sensitive issues. The respondent is not given any possible answers to choose from.

  o E.g. Can you describe factors responsible for adoption of Maize?

- Generally one can analyse and just describe the main data (variables).

- One can also re-code and categorize open-ended questions or transcribe qualitative data (interviews) in quantitative, edit and check and prepare tables for statistical analysis.

  - Depending the re-coding and categorization variable be nominal, ordinal interval/ratio.

Closed questions

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- Closed questions offer a list of possible options or answers from which the respondents must choose.

- Close uestions must be exhaustive (complete) and mutually exclusive(can't happen at the same time)

- E.g. Marital status 1. Single [ ] 2. Married [ ] 3. separated/divorced/widowed [ ].

- Close questions can also be given for respondents to indicate their opinions by choosing rating points on a scale.
- NOTE: the possible options has implicaions for analysis

The Likert Scale /Likert response format

- Likert Scale
  - Write a series of verbal statements that expressed a range of positive expressions, views, sentiments, claims or opinions about the "attitude object (underlying construct)"

  - Participants may answer: Strongly Disagree, Disagree, Neither Agree nor Disagree (Neutral?), Agree or Strongly Agree.

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- Most popular attitudinal measure
- Relatively easy to construct
- Easy for respondents to complete – most   subjects familiar with the scale
- Easy to score and analyze
- Not extreme or ambiguous
- Statements should NOT contain conjunctions
- Fewest but with validity/reliability
- Readability
- Can be competency lists

Implications for analysis

- The need for "reverse item scoring"
  - Ranged from mildly positive to strongly positive and then the same relative to a range of negative statements.

- Some Arguments:
- Likert scale items should be analyzed separately
  - It depends on how items are constructed
- Because Likert scales are ordinal-level scales, only non-parametric statistical tests should be used with them.
    - Studies show Likert response formats can be:
      - *Interval Scales,*
      - *Ratio scales logically with the correct anchoring terms.*

Ilustrations

- Rate how well the following extension goals are being achieved under the Decentralized Extension system. Use the scale below 1 = Strongly Disagreed , 2 = Disagreed 3 = Neutral, 4 = Agreed, 5= Strongly Agreed

Aspect of extension	Level of Achievement					
Helped mallholder farmers adopt agricultural innovations.	1	2	3	4	5	
Promoted smallholder farmers' participation in development decision-making.	1	2	3	4	5	
Facilitated integrated rural development and poverty reduction strategy programs.	1	2	3	4	5	
Helped farmers gain access to credit/farm inputs/markets	1	2	3	4	5	
Advised government on extension policy	1	2	3	4	5	
Facilitated coordination across departments in the Ministry of Agriculture.	1	2	3	4	5	
Made extension financially self-sustainable/cost recovering.	1	2	3	4	5	
Mobilized the youth for agricultural/rural development.	1	2	3	4	5	

Illustration

- What is your perceived skill level in e-agriculture programme planning?
- Rate your perceived level of skills participation on a scale of: 5= Very high; 4= high; 3= medium; 2= Low; 1= Very low and 0 if you have no skill in the activity.

Programme planning	Level of participation					
Identifying problem on e-agriculture programme	0	1	2	3	4	5
Providing solutions to e-agriculture programme	0	1	2	3	4	5
Evaluating alternate solution to problems on e-agriculture	0	1	2	3	4	5
Determining objectives of e-agriculture programme	0	1	2	3	4	5
Determining the resources for e-agriculture	0	1	2	3	4	5
Identifying stakeholders for e-agriculture	0	1	2	3	4	5

Thank you

- Formulate a number of questions that are directly related to aspect of your objectives/ topic as well as Secondary and tertiary questions

- Self-critique the questions. Here look for the following for: Ambiguous , non specific questions or question lacking of clarity

- Leading, double-barreled and presuming questions should not be employed

- Make an attempt to make questions as neutral as possible.

- Personalized, embarrassing, sensitive or threatening questions
- Avoid vague words and academic jargon e.g. "Regularly", "always" "rarely" "often".
- NB you should explain what is meant by that, e.g.
- How many times did FLS visited you last month?. Is likely to elicit a more accurate response

- Language - use simple language (possibly that of the respondent), without jargon, slang or complicated extensions. Technical terms should only be used if respondent can understand such terms.

- Questions should not be too demanding that which will make respondent to refer to sources or make complicated calculations before they give a response.

- Each question must ask what it is suppose to ask

- External scrutiny- Give to experts and colleagues with practical expertise in that field of investigation.

- Re-examination and revision -The critique offered by experts should be considered and eventual changes implemented.

- Pre-test or conduct pilot study - It is done to check suitability of instruments as a whole or some aspects of it. A small sample is selected for this purpose, the results are then analysed and interpreted.

- Revision - Changes that occur in pre-test/pilot study are corrected. There might be the need for second pre-test if changes are major.

- Formulation of final draft. In formulating the final draft,
- Editing the text
- Checking for spelling mistakes
- Legibility
- Instructions - regarding the way answering questions, e.g. Circle appropriate   no, tick box etc.
- Layout - well presented; easy to read, easy to follow
- Space for respondents, to give answers
- General presentation of questionnaire
- Cover letter heads with aims to study

Thank you