Sample training material for RED

Table 2: Rubric for Experimental Design (RED)

Areas of Difficulty	**Propositional Statements/Completely Correct Ideas**	**Typical Evidence of Difficulties**	**Example of difficulties from the 'Drug Assessment'**
(1) Variable Property of an Experimental Subject	**Experimental subject or units:** The individuals to which the specific variable treatment or experimental condition is applied. An experimental subject has a variable property. A variable is a certain property of an experimental subject that can be measured and that has more than one condition.	**a.** An experimental subject was considered to be a variable.	
		b. Groups of experimental subject were considered based on a property *that diverges* from the subjects that were the target for the stated investigation or claim to be tested.	"Participants cannot be pregnant simply because it will affect the fetus differently than the adult. People older than 35 should not test the drug…"
		c. Variable property of experimental subject considered is not consistent throughout a proposed experiment.	
(2) Manipulation of Variables	**Testable hypothesis:** A hypothesis is a testable statement that carries a predicted association between a treatment and outcome variable. (Ruxton and Colegrave, 2006).	**a.** Only the treatment and/or outcome variable is present in the hypothesis statement.	"The drug is effective on people with high blood pressure"
		b. Hypothesis does not clearly indicate the expected outcome to be measured from a proposed experiment.	"This drug will be administered to people at low dosages at first, then we will record results and from there calculate the correct amount of Alamain that should be given to each person"
	Treatment group: A treatment group of experimental subjects or units is exposed to experimental conditions that vary in a specific way (Holmes, Moody and Dine, 2011).	**c.** Haphazard assignment of treatments to experimental units in a manner inappropriate for the goal of an experiment.	
		d. Treatment conditions proposed are unsuitable physiologically for the experimental subject or inappropriate according to the goal of an investigation.	"Experimental groups will receive a couple different dosages to see how each dose affects blood pressure"
	Combinatorial reasoning: In experimental scenarios when two or more treatment (independent) variables are present simultaneously, all combined manipulations of both together are examined to observe combinatorial effects on an outcome.	**e.** Independent variables are haphazardly applied, in scenarios when the combined effects of two independent variables are to be tested simultaneously.	
		f. Combining treatments in scenarios where the effect of two different treatments are to be	

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		determined individually	
	Controlling outside variables: The control and treatment groups are required to be matched as closely as possible to equally reduce the effect of lurking variables on both groups (Holmes, Moody and Dine, 2011).	**g.** Variables unrelated to the research question (often showing a prior knowledge bias) are mismatched across treatment and control groups.	"[Factors like] *sleep or awake and body position- lying down, sitting or standing* [should be constant across experimental groups]"
	Control group: A control group of experimental subjects or units, for comparison purposes, measures natural behavior under a normal condition instead of exposing them to experimental treatment conditions. Parameters other than the treatment variables are identical for both the treatment and control conditions. (Gill and Walsh, 2010; Holmes, Moody and Dine, 2011).	**h.** The control group does not provide natural behavior conditions because absence of the variable being manipulated in the treatment group, results in conditions unsuitable for the experimental subject.	
		i. Control group treatment conditions are inappropriate for the stated hypothesis or experiment goal.	"The control group will be comprised of all identical types of people will similar body types and lifestyles."
		j. Experimental subjects carrying obvious differences are assigned to treatment vs. control group.	"The younger, healthier participants will be the experimental group while the not so young will be the control."
(3) Measurement of Outcome	Treatment and outcome variables should match up with proposed measurements or outcome can be categorical and/or quantitative variables treatments A categorical variable sorts values into distinct categories. A quantitative or continuous variable answers a "how many?" type question and usually would yield quantitative responses.	**a.** No coherent relationship between a treatment and outcome variable is mentioned.	"How many people can be helped by this drug will determine its success"
		b. The treatment and outcome variables are reversed.	"The clinical trials of this drug will be successful by lowering patient's blood pressure"
	Outcome group: The experimental subject carries a specific outcome (dependent variable) that can be observed/measured in response to the experimental conditions applied as part of the treatment (Holmes, Moody and Dine, 2011).	**c.** Outcome variables proposed are irrelevant for the proposed experimental context provided or with the hypothesis.	"Regular testing of blood coagulation would be taken to measure if the blood gets thinner or thicker"
		d. Stated outcome not measurable.	"Long term blood pressure recovery is the best method to make sure the pressure remains low forever and not just when initially taken."

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		e. No measure was proposed for the outcome variable.	
		f. An outcome variable was not listed for an investigation.	"If the results observed in the human experiment is the same, or similar, to that observed in the animal experiment, and then the drug is a success. If the results are completely different, then the drug is a failure."
		g. There is a mismatch between what the investigation claims to test and the outcome variable.	"If the drug does indeed reduce blood pressure, the percentage of those who [se] blood pressure [becomes] normal will be significantly high than that control group"
(4) Accounting for Variability	Experimental design needs to account for the variability occurring in the natural biological world. Reducing variability is essential to reduce effect of non-relevant factors in order to carefully observe effects of relevant ones (Box *et al.* 2005; Cox and Reid 2000).	**a.** Claims that a sample of experimental subjects will eliminate natural variability with those subjects.	"Control group will be comprised of all identical types of people"
	Selection of a random (representative) sample: A representative sample is one where all experimental subjects from a target demographic have an equal chance of being selected in the control or treatment group. An appropriate representative sample size is one that averages out any variations not controlled for in the experimental design. (The College Board, 2006; Holmes, Moody and Dine, 2011).	**b.** Criteria for *selecting* experimental subjects for treatment vs. control group are biased and not uniform.	"The control group will be comprised of all identical types of people with similar body types and lifestyles. The experimental group can have more of a variation and will be administered with the drug."
		c. Criteria for selecting experimental subjects for investigation are different in a way that is not representative of the target population.	"People older than 35 should not test the drug. These criteria need to be met and not taken lightly because health problems may arise."
	Randomized design of an experiment: Randomizing the order in which experimental subjects or units experience treatment conditions as a way to reduce the chance of bias in the experiment (Ramsey and Schafer, 2012). Randomization can be complete or restricted. One can	**d.** Decisions to *assign* experimental subjects to treatment vs. control group are not random but biased for each group.	"The younger, healthier participants will be the experimental group while the not so young will be the control"
		e. Random assignment of treatments is not considered.	[To assign participants] the control group will have identical people with similar

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	restrict randomization by using block design which accounts for known variability in the experiment that can't be controlled.		lifestyles and experimental group can have variation."
		f. Random assignment of treatments is incomplete as they show random assignment of the experimental subjects but instead, what is needed is random assignment of treatments.	
	Replication of treatments to experimental units or subjects: Replication is performed to assess natural variability, by repeating the same manipulations to several experimental subjects (or units carrying multiple subjects), as appropriate under the same treatment conditions (Quinn and Keough, 2002).	**g.** Replication means repeating the entire experiment *at some other time* with another group of experimental subjects.	"Whether others can redo this experiment with other participants later and get the same result"
		h. No evidence of replication or suggested need to replicate as a method to access variability or to increase validity/power of an investigation.	
(5) Scope of Inference of Findings	**Scope of inference:** Recognizing the limit of inferences that can be made from a small characteristic sample of experimental subjects or units, to a wider target population and knowing to what extent findings at the experimental subject level can be generalized.	**a.** The inference from a sample is to a different target population. Usually students under- or overestimate their findings beyond the scope of the target population.	"health, hemoglobin, smoking, age under 35, and pregnancy status"
		b. No steps are carried out to randomly select experimental subjects' representative of the target population about which claims are made.	
	Cause and effect conclusions: A cause-and-effect relationship can be established as separate from a mere association between variables only when the effect of lurking variables are reduced by random assignment of treatments and matching treatment and control group conditions as closely as possible. Appropriate control groups also in comparison to the treatment group also need to be considered (NIST/SEMATECH, 2003; Wuensch, 2001).	**c.** A causal relationship is claimed even though the data shows only association between variables. Correlation does not establish causation. (NIST/SEMATECH, 2003)	"health, hemoglobin, smoking, age under 35, and pregnancy status"