

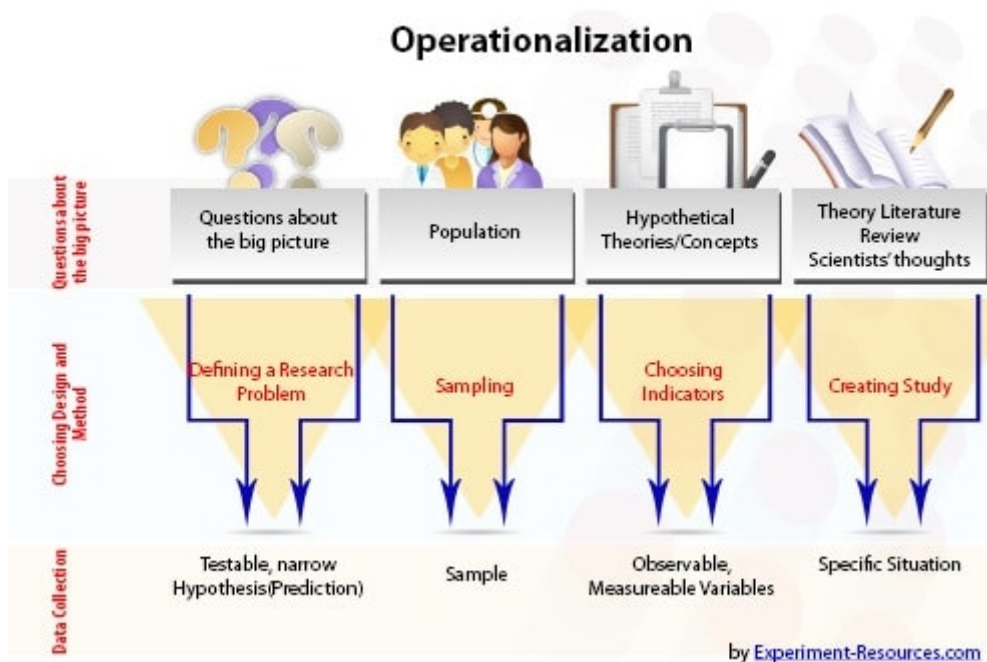
## Operationalization

Martyn Shuttleworth328K reads

Operationalization is the process of strictly defining variables into measurable factors. The process defines fuzzy concepts and allows them to be measured, empirically and quantitatively.

For experimental research, where interval or ratio measurements are used, the scales are usually well defined and strict.

Operationalization also sets down exact definitions of each variable, increasing the quality of the results, and improving the robustness of the design.



For many fields, such as social science, which often use ordinal measurements, operationalization is essential. It determines how the researchers are going to measure an emotion or concept, such as the level of distress or aggression.

Such measurements are arbitrary, but allow others to replicate the research, as well as perform statistical analysis of the results.

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## Fuzzy Concepts

Fuzzy concepts are vague ideas, concepts that lack clarity or are only partially true. These are often referred to as "conceptual variables [1]".

It is important to define the variables to facilitate accurate replication of the research process [2]. For example, a scientist might propose the hypothesis [3]:

"Children grow more quickly if they eat vegetables."

**What does the statement mean by 'children'?** Are they from America or Africa. What age are they? Are the children boys or girls? There are billions of children in the world, so how do you define the sample groups?

**How is 'growth' defined?** Is it weight, height, mental growth or strength? The statement does not strictly define the measurable, dependent variable [4].

**What does the term 'more quickly' mean?** What units, and what timescale, will be used to measure this? A short-term experiment, lasting one month, may give wildly different results than a longer-term study.

The frequency of sampling [5] is important for operationalization [6], too.

If you were conducting the experiment over one year, it would not be practical to test the weight every 5 minutes, or even every month. The first is impractical, and the latter will not generate enough analyzable data points.

**What are 'vegetables'?** There are hundreds of different types of vegetable, each containing different levels of vitamins and minerals. Are the children fed raw vegetables, or are they cooked? How does the researcher standardize diets, and ensure that the children eat their greens?

## Operationalization

The above hypothesis [3] is not a bad statement, but it needs clarifying and strengthening, a process called operationalization.

The researcher could narrow down the range of children, by specifying age, sex, nationality, or a combination of attributes. As long as the sample group is representative of the wider group, then the statement is more clearly defined.

Growth may be defined as height or weight. The researcher must select a definable and measurable variable, which will form part of the research problem [7] and hypothesis.

Again, 'more quickly' would be redefined as a period of time, and stipulate the frequency of sampling. The initial research design could specify three months or one year, giving a reasonable time scale and taking into account time and budget restraints.

Each sample group could be fed the same diet, or different combinations of vegetables. The researcher might decide that the hypothesis could revolve around vitamin C intake, so the vegetables could be analyzed for the average vitamin content.

Alternatively, a researcher might decide to use an ordinal scale of measurement, asking subjects to fill in a questionnaire [8] about their dietary habits.

Already, the fuzzy concept has undergone a period of operationalization, and the hypothesis takes on a testable [9] format.

## The Importance of Operationalization

Of course, strictly speaking, concepts such as seconds, kilograms and centigrade are artificial constructs, a way in which we define variables.

Pounds and Fahrenheit are no less accurate, but were jettisoned in favor of the metric system. A researcher must justify their scale of scientific measurement [10].

Operationalization defines the exact measuring method used, and allows other scientists to follow exactly the same methodology. One example of the dangers of non-operationalization is the failure of the Mars Climate Orbiter [11].

This expensive satellite was lost, somewhere above Mars, and the mission completely failed. Subsequent investigation found that the engineers at the sub-contractor, Lockheed, had used imperial units instead of metric units of force.

A failure in operationalization meant that the units used during the construction and simulations were not standardized. The US engineers used pound force, the other engineers and software designers, correctly, used metric Newtons.

This led to a huge error in the thrust calculations, and the spacecraft ended up in a lower orbit around Mars, burning up from atmospheric friction. This failure in operationalization cost hundreds of millions of dollars, and years of planning and construction were wasted.

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**Links**

- [1] <https://explorable.com/conceptual-variables>
- [2] <https://explorable.com/steps-of-the-scientific-method>
- [3] <https://explorable.com/research-hypothesis>
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