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Basics of Scientific Research

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«ЛитРес: Самиздат»

2019

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Basics of Scientific Research / К. Алтунин — «ЛитРес: Самиздат», 2019

A book highlights the main basics of scientific knowledge. There is a way how to beef up true knowledge and not to go astray at the beginning of the research process. Some examples, principles, methodology issues are given for understanding what's Science and its basics, how to start new steps on scientific research if it has never been done before, and no experience has been acquired. The book will be useful for people who would like to pay attention to the first steps in science and understand methods of scientific research.

Константин Алтунин
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Preface

The idea to create such a book was born earlier, and I would say much earlier than the date of its publishing. The reason was that I studied as a post-graduate student and was forced to pass examinations one of which touched upon the basis of scientific knowledge and philosophy of science.

Nowadays we live in the up-to-date changeable world and still try to beef up true knowledge about laws of it, not only laws of physics that seem to be discovered and passed hard during long ages from the sir Newton till the physician Einstein, from discovery of a wheel up to the appearance of nuclear reactors… It's just obvious for the part of our life we solve easy and simultaneously complicated tasks, we are keen on to obtain so-called clear understanding this world where we constantly dwell.

And, first of all, we get the need for basis of scientific knowledge. Because while knowing and comprehending not only its worship Science, but also its formation, we can bravely go ahead for new discoveries.

The book consists of several parts with their own captions where you can get the most necessary information. The great attention is paid to methods and forms of scientific knowledge.

What is Research?

In the broadest sense of the word, the definition of research includes any gathering data, information and facts for advancement of knowledge.

Science does not use this word in the same way, preferring to restrict it to certain narrowly defined areas. The word 'review' is more often used to describe the learning process which is one of the underlying tenets of rigid structures defining scientific research.

Definition of research

When you say that you are undertaking a research study to find answers to a question, you are implying that the process:

1. is being undertaken within a framework of a set of philosophies (approaches);
2. uses procedures, methods and techniques that have been tested for their validity and reliability;
3. is designed to be unbiased and objective.

Validity means that correct procedures have been applied to find answers to a question. Reliability refers to the quality of a measurement procedure that provides repeatability and accuracy. Unbiased and objective means that you have taken each step in an unbiased manner and drawn each conclusion to the best of your ability and without introducing your own vested interest. (Bias is a deliberate attempt to either conceal or highlight something).

Adherence to the three criteria mentioned above enables the process to be called 'research'. However, the degree to which these criteria are expected to be fulfilled varies from discipline to discipline and so the meaning of 'research' differs from one academic discipline to another. The difference between research and non-research activity is, in the way we find answers: the process must meet certain requirements to be called research. We can identify these requirements by examining some definitions of research. The word research is composed of two syllables, re and search. So re is a prefix meaning again, anew or over again, search is a verb meaning to examine closely and carefully, to test and try, or to probe. Together they form a noun describing a careful, systematic, patient study and investigation in some field of knowledge, undertaken to establish facts or principles. Research is a structured enquiry that utilizes acceptable scientific methodology to solve problems and create new knowledge that is generally applicable. Scientific methods consist of systematic observation, classification and interpretation of data. Although we engage in such process in our daily life, the difference between our casual day- to-day generalisation and the conclusions usually recognized as scientific method lies in the degree of formality, rigorousness, verifiability and general validity of latter.

Characteristics of research

Research is a process of collecting, analyzing and interpreting information to answer questions. But to qualify as research, the process must have certain characteristics: it must, as far as possible, be controlled, rigorous, systematic, valid and verifiable, empirical and critical.

Controlled – in real life there are many factors that affect an outcome. The concept of control implies that, in exploring causality in relation to two variables (factors), you set up your study in a way that minimizes the effects of other factors affecting the relationship. This can be achieved to a large extent in the physical sciences (Cookery, Bakery), as most of research is done in a laboratory. However, in the social sciences (Hospitality and Tourism) it is extremely difficult as research is carried out on issues related to human beings living in society, where such controls are not possible. Therefore in Hospitality and Tourism, as you cannot control external factors, you attempt to quantify their impact.

Rigorous – you must be scrupulous in ensuring that the procedures followed to find answers to questions are *relevant, appropriate and justified.* Again, the degree of rigor varies markedly between the physical and social sciences and within the social sciences.

Systematic – this implies that the procedure adopted to undertake an investigation follows a certain logical sequence. The different steps cannot be taken in a haphazard way. Some procedures must follow others.

Valid and verifiable – this concept implies that whatever you conclude on the basis of your findings is correct and can be verified by you and others.

Empirical – this means that any conclusion drawn are based upon hard evidence gathered from information collected from real life experiences or observations.

Critical – critical scrutiny of the procedures used and the methods employed is crucial to a research enquiry. The process of investigation must be foolproof and free from drawbacks. The process adopted and the procedures used must be able to withstand the most critical scrutiny.

For a process to be called research, it is imperative that it has the above characteristics.

Types of research

Research can be classified from three perspectives:

1. Application of research study
2. Objectives in undertaking the research
3. Inquiry mode employed

Application:

From the point of view of application, there are two broad categories of research: *pure research* and *applied research.*

Pure research involves developing and testing theories and hypotheses that are intellectually challenging to the researcher but may or may not have practical application at the present time or in the future. *The knowledge produced through pure research is sought in order to add to the existing body of research methods. Applied research* is done to solve specific, practical questions; for policy formulation, administration and understanding of a phenomenon. It can be *exploratory*, but is usually *descriptive*. It is almost always done on the basis of basic research. Applied research can be carried out by academic or industrial institutions. Often, an academic institution such as a university will have a specific applied research program funded by an industrial partner interested in that program.

Objectives:

From the viewpoint of objectives, a research can be classified as

– *descriptive;*

– *correlational;*

– *explanatory;*

– *exploratory.*

Descriptive research attempts to describe systematically a situation, problem, phenomenon, service or programme, or provides information about, say, living condition of a community, or describes attitudes towards an issue. *Correlational research* attempts to discover or establish the existence of a relationship/ interdependence between two or more aspects of a situation. *Explanatory research* attempts to clarify why and how there is a relationship between two or more aspects of a situation or phenomenon. *Exploratory research* is undertaken to explore an area where little is known or to investigate the possibilities of undertaking a particular research study (*feasibility study/pilot study). In practice most studies are a combination of the first three categories.*

Inquiry Mode:

From the process adopted to find answer to research questions – the two approaches are:

– *Structured approach;*

– *Unstructured approach.*

Structured approach:

The structured approach to inquiry is usually classified as *quantitative research.* Here everything that forms the research process such as objectives, design, sample, and questions that you plan to ask. It is more appropriate to determine the extent of a problem, issue or phenomenon by quantifying the variation, e.g., how many people have a particular problem? How many people hold a particular attitude?

Unstructured approach:

The unstructured approach to inquiry is usually classified as *qualitative research.* This approach allows flexibility in all aspects of the research process. It is more appropriate to explore the *nature* of a problem, issue or phenomenon *without quantifying it.* The main objective is to describe the *variation* in a phenomenon, situation or attitude, e.g., description of an observed situation, the historical enumeration of events, an account of different opinions different people have about an issue, description of working condition in a particular industry.

Both approaches have their place in research. Both have their strengths and weaknesses. In many studies you have to combine both qualitative and quantitative approaches. For example, suppose you have to find the types of cuisine/accommodation available in a city and the extent of their popularity. *Types of cuisine* is the qualitative aspect of the study as finding out about them entails description of culture and cuisine. The *extent of their popularity* is the quantitative aspect as it involves estimating the number of people who visit a restaurant serving such cuisine and calculating the other indicators that reflect the extent of popularity [2, 3, 4].

Science

Here are some common definitions of science:

– Branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws, e.g., the mathematical science;

– Systemic knowledge of the physical or material world gained through observations and experimentation;

– Systematized knowledge in general;
– Any of the branches of natural or physical sciences;
– A particular branch of knowledge;
– Knowledge, as of facts or principles; knowledge gained by systematic study;
– Skill, esp. reflecting a precise application of facts or principle; proficiency.

The word Science comes from Latin word "scientia" meaning "knowledge" and in the broadest sense it is any systematic knowledge-base or prescriptive practice being capable of resulting in prediction. This is why science is termed as highly skilled technique or practice. However, in more contemporary terms, science is a system of acquiring knowledge based on scientific process or method in order to organize body of knowledge gained through research. Science remains a continuing effort on the part of human being to discover and increase knowledge through research. Scientists can make observations, record measureable data related to their observations, analyze the information in hand in order to construct theoretical explanations of phenomenon involved.

Man's respect for knowledge is one of his most peculiar characteristics. Science came to be the name of the most respectable kind of knowledge. But what distinguishes knowledge from superstition, ideology or pseudoscience? The Catholic Church excommunicated Copernicans, the Communist Party persecuted Mendelians on the ground that their doctrines were pseudoscientific. The demarcation between science and pseudoscience is not merely a problem of armchair philosophy: it is of vital social and political relevance. Many philosophers have tried to solve the problem of demarcation in the following terms: a statement constitutes knowledge if many people believe it sufficiently strongly. But the history of thought shows us that many people were totally committed to absurd beliefs. If the strength of beliefs were a hallmark of knowledge, we should have to rank some tales about demons, angels, devils, and of heaven and hell as knowledge. Scientists, on the other hand, are very skeptical even of their best theories. Newton's is the most powerful theory science has yet produced, but Newton himself never believed that bodies attract each other at a distance. So no degree of commitment to beliefs makes them knowledge. Indeed, the hallmark of scientific behaviour is a certain skepticism even towards one's most cherished theories. Blind commitment to a theory is not an intellectual virtue: it is an intellectual crime. Thus a statement may be pseudoscientific even if it is eminently 'plausible' and everybody believes in it, and it may be scientifically valuable even if it is unbelievable and nobody believes in it. A theory may even be of supreme scientific value even if no one understands it, let alone believes it [5].

Scientific knowledge

Scientific knowledge has got its own levels [1]. From the school bench you probably heard many times that there could be something like empirical and theoretical, and, on the other hand, there is still a great feasibility you knew about such a difference being a student or a full-time specialist at any sphere of work. So, empirical and theoretical levels are two different floors of scientific knowledge that comprise their unique and general forms and methods. Let’s look at Fig. 1, where you can see a so-called scientific knowledge block. The author decided to show it up in 3D because it would be more picturesque and, in addition, shorter to be reviewed.

Well, if we take into consideration first empirical level, we see it has such unique methods as experiment and observation, and own forms such as protocol suggestions, data, phenomenological theories, laws.

And theoretical level has own methods including idealization, formalization, from the abstract to the concrete, and unique forms including theory and hypothesis.

But if we try to look at the highest flatness, we can notice general methods and general forms that can belong both to empirical and theoretical levels.

From this first step let's make an attempt to describe all of them and give them definitions and interpretations.

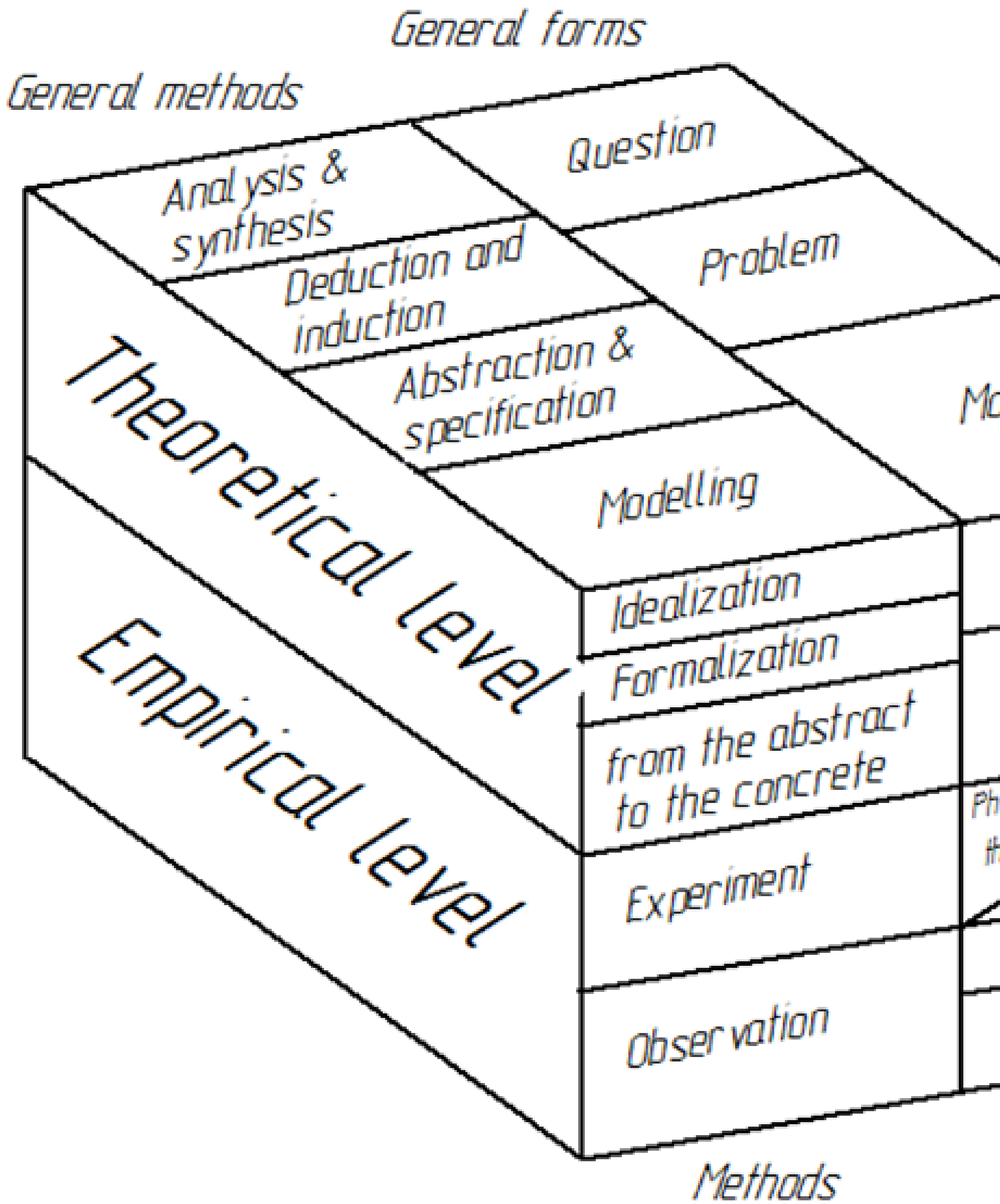

Fig. 1. Scientific Knowledge Block

Observation

Observation is an active acquisition of information from a primary source. In living beings, observation employs the senses. In science, observation can also involve the recording data via the use of instruments. The term may also refer to any data collected during the scientific activity. Observations can be qualitative, that is, only the absence or presence of a property is noted, or quantitative if a numerical value is attached to the observed phenomenon by counting or measuring.

Observation in Science

The scientific method requires observations of nature to formulate and test hypotheses. It consists of these steps:

1. Asking a question about a natural phenomenon.
2. Making observations of the phenomenon.
3. Hypothesizing an explanation for the phenomenon.
4. Predicting a logical consequence of the hypothesis.
5. Testing the hypothesis by an experiment, an observational study, or a field study.
6. Creating a conclusion with data gathered in the experiment, or forming a revised/new hypothesis and repeating the process.

Observations usually play a role in the second and fifth steps of the scientific method. However, the need for reproducibility requires that observations by different observers can be comparable. Human sense impressions are subjective and qualitative making them is difficult to record or compare, shared by all observers, and counting how many of the standard units are comparable to the object. Measurement reduces an observation to a number which can be recorded, and two observations which result in the same number are equal within the resolution of the process.

Senses are limited, and are a subject to errors in perception such as optical illusion. Scientific instruments were developed to magnify human powers of observation, such as weighing scales, clocks, telescope, microscopes, thermometers, cameras, and also translate into perceptible form events that are unobservable by human senses, such as indicator dyes, voltmeters, spectrometers, infrared cameras, oscilloscopes, interferometers, x-ray machines and radio receivers, etc.

Observations in philosophy

"Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and to make new ones like them."

– Meditations. iv. 36. – Marcus Aurelius

Observation in philosophical terms is a process of filtering sensory information through the thought process. Input is received via hearing, sight, smell, taste or touch and then analyzed through either rational or irrational thought. You can *see* a parent beat his child; you *observe* that such an action is either good or bad.

Deductions about what behaviors are good or bad may be based in no way on preferences about building relationships, or study of the consequences resulting from the observed behavior. With the passage of time, impressions stored in the consciousness about many related observations, together with the resulting relationships and consequences, permit the individual to build a construct about the moral implications of behavior.

Experiment

Experiment is an orderly procedure carried out with the goal of verifying, refuting or establishing the validity of a hypothesis. Experiments provide insight into cause-and-effect by demonstrating what outcome occurs when a particular factor is manipulated. Experiments vary greatly in their goal and scale, but always rely on repeatable procedure and logical analysis of the results. There are also existing natural experimental studies.

A child may carry out basic experiments to understand gravity, while teams of scientists may take years of systematic research to advance the understanding of a phenomenon. Experiments and other types of hands-on activities are very important to student learning in a science classroom. Experiments can raise test scores and help a student become more engaged and interested in the material they are learning, especially when used over time. Experiments can vary from personal and informal natural comparisons (e.g. tasting a range of chocolates to find a favorite one), to highly controlled (e.g. tests requiring complex apparatus overseen by many scientists that hope to discover information about subatomic particles). Uses of experiments vary considerably between the natural and human sciences.

Experiments typically include control, which are designed to minimize the effects of variables other than the single independent variable. This increases the reliability of the results, often through a comparison between control measurements and other ones.

Scientific controls are a part of the scientific method. Ideally, all variables in an experiment will be controlled (accounted for by the control measurements) and none will be uncontrolled. In such an experiment, if all the controls work as expected, it is possible to conclude that the experiment is working as intended and that the results of the experiment are due to the effect of the variable being tested.

Designs of Experiment

The types of Experimental Designs usually include a Completely Randomized Design, a Randomized Block Design and a Matched Pairs Design [6].

In a Completely Randomized Design each experimental unit is randomly assigned to a random group to receive a different treatment, each unit in the same group receives the same treatment, and at the end of experiment you will compare the results from each treatment (Fig. 2, Fig. 3). Let's show up how a Completely Randomized Design would be used in the following example:

A researcher wants to conduct an experiment to determine which environment is best suited for studying – a library, in one's own room or outside. A total of 30 university students volunteer to participate in the experiment. So we have three treatments such as the library, in one's own room or outside. Since we have three treatments we will have three groups receiving the treatments, and since there are 30 university students, these 30 subjects will be randomly assigned to the three groups to receive the treatments.

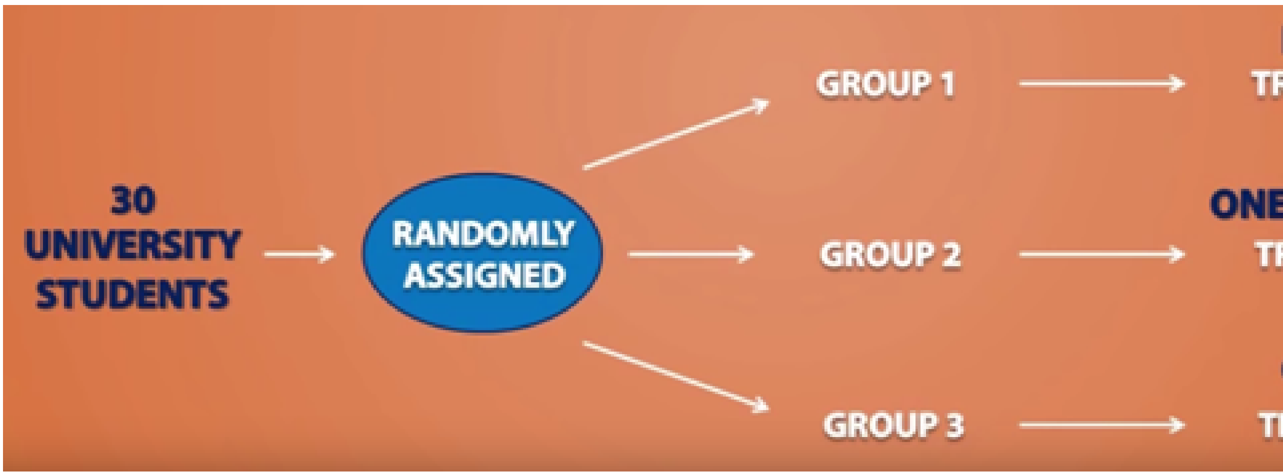

Fig. 2. Completely Randomized Design

And at the end of the experiment we will compare results from each treatment.

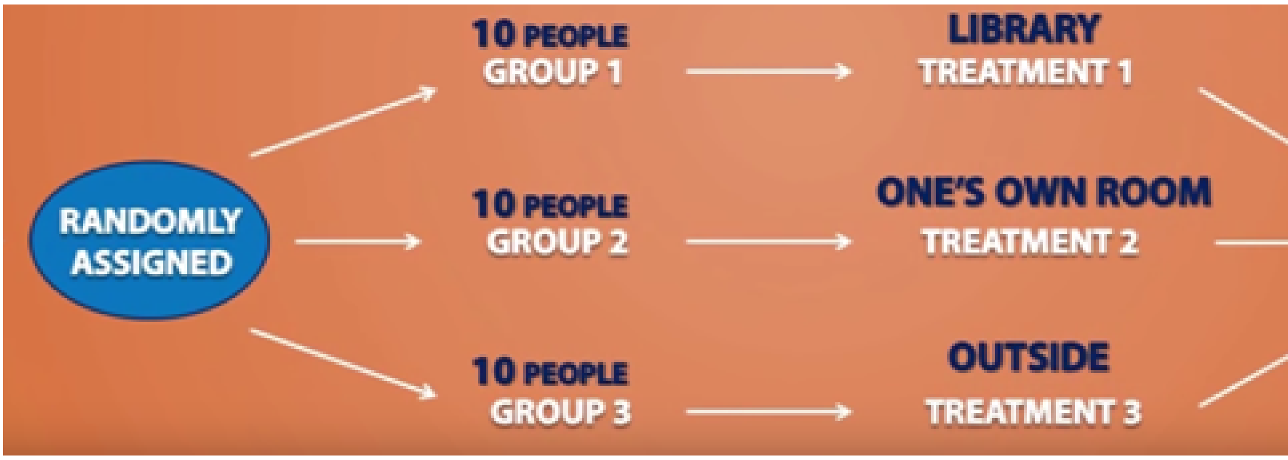

Fig. 3. Completely Randomized Design

Let's see that a researcher believes that gender has an effect on the results. In a case like this we would use a Randomized Block Design that doesn't immediately randomly assign the experiment units to receive treatments, we, first, assign people into a block based on the characteristic that's expected to influence the response to its treatments. And this example where gender would be a blocking variable, so first we separate the experimental units based on gender, one block will be for females and one block will be for males. There are 18 females and 12 males (Fig. 4).

Конец ознакомительного фрагмента.