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Levels, Objectives and Variables in Scientific Research

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Abstract

It is common to use Bloom's taxonomy to write research objectives; however, it is often forgotten that this Bloomian classification corresponds to the teaching–learning process. Likewise, is not usual to include the levels or scope of research since so many classifications have been proposed, suggesting that science can be fragmented and that qualitative studies have nothing to do with quantitative studies and vice versa. Regardless of the coincidences and discrepancies that may exist, researchers require a guideline that is based on the principles of science to be able to organize and structure their studies and that allows for growth and development, removing biases and partialities from analysis. It is necessary to remember that a taxonomy is valid if it adheres to the criteria that scientific knowledge itself indicates. This research is an exploratory and observational study whose purpose is to identify its objectives according to its levels with their respective study variables.

Keywords: *Levels, Objectives, Principles, Science, Research*

INTRODUCTION

Taxonomy is the science that is responsible for the classification of the various aspects of a body of scientific knowledge, that is, its hierarchy and ordering (Manassero-Mas & Vásquez-Alonso, 2019). There are three principles that must be taken into account to present a taxonomy in the field of science: a) the principle of exhaustiveness, which indicates that the study carried out must be of the degree of the classification that is being carried out (Marradi, 1990); b) the exclusion principle, which indicates that once the study is located in one of the levels of the classification, it can no longer occupy another (Margenau, 2022); (Gamow, 1959); c) the principle of parsimony, which allows us to state that the simplest explanation is the one that is closest to reality (Goloboff, 2003); (Sober, 1981). Added to this is the alignment criterion, which expresses that the problem and research objectives must correspond to a taxonomy and the same level of scientific inquiry (Ochoa-Pachas & Yunkor-Romero, 2021). In universities, levels, problems, and research objectives are often confused, using nouns and verbs that do not correspond to the investigative degrees, generating difficulties when evaluating research (Supo & Zacarías, 2020). This violates the aforementioned principles and, further, produces uncertainty in the work presented. Although there is a theory that indicates that concepts have different meanings from different perspectives (Derrida, 1989), it must be remembered that science corrects itself to grow and develop (Bunge, 2017).

Investigative processes must have a minimum level of rigor, using fully defined constructs, taking into consideration their characteristics, properties, functions, applications, and uses, among others (Lavado, 2018). If the research is framed in inductive studies, the exploratory, descriptive, and relational levels must be taken into account; if the investigations are deductive, the explanatory, predictive, applicative, and technological levels must be taken into account (Supo & Zacarías, 2020). However, if the statement of the study is descriptive, the problem is relational, and the objective is exploratory, then the principles of exhaustiveness, exclusion, and parsimony and the alignment criterion are broken, the consequence of which is that the work is methodologically deficient. This implies that there is no coherence or methodological cohesion, and there is no bridge between epistemology, logic, the procedural aspect, and technique because they are disconnected, which is an extremely notable weakness (V Encuentro Latinoamericano de Metodología de las CIencias Sociales, 2016).

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Statement, Title, Problem, And Research Variables

Within logic, a statement is a proposition that can be true or false (Tantray, 2016). Based on the statement the title of the research is constructed. This title must have four components: a) the purpose of the study (Abusaleh & Anwar, 2022); b) the line of research (Cerda, 2004); c) the study population (Nguyen et al., 2023); and d) the space–time dimension (Pant et al., 2018). The purpose of the study relates to the analytical intention, which ranges from exploration, description, relationship, explanation, and prediction to application; the line of research must consist of the study variable or variables; the study population is the unit that is going to be analyzed and that will allow for deeper knowledge of the topic (Arias-Gómez et al., 2016); and the space–time dimension indicates where and at what time the study will be carried out (Hernández et al., 2014).

If the title, which is derived from the statement of the study, is well constructed, the main or general problem is obtained; the title is transformed into a question, taking into consideration the purpose of the study that is linked to the levels of research, to the lines of research that are associated with the variable(s), to the population that is made up of the study units, where, if necessary, a sample that represents the population is obtained, and, finally, the space–time dimension, which implies the place where the events take place and the time where they occurred. This sequence is important, especially if one has an adequate scientific education (Aldúriz-Bravo, 2020).

The purpose of the study and the line of research are closely related because the analytical intention will allow one to designate a name for the variable or variables that are part of the line of research (Sinha & Majumder, 2021). That is, if the purpose is exploratory, the variables are holistic and subjective (Guerrero, 2016). The line of research is made up of categories, which have to be broken down, leading to subcategories, but these are not measured or counted; on the other hand, if the analytical intention is description, then the work has a single analytical variable, which will be subjected to statistics, either descriptive or inferential. What would this variable be called? Dependent? Independent? The answer is neither because the purpose is aimed at describing and establishing whether the population being studied has some relationship with a larger population to see if the factors that accompany the variable being studied are in the corresponding area. This is why the study variable is called the variable of interest, and it is the one that must be characterized; at the same time, it must be established whether there are factors that surround it or are going to influence it (Supo, 2015).

When the purpose of the study is relational, that is, working with two analytical variables, three aspects are sought: whether there is a link between the two variables, how strong that link is, and whether the association is direct or positive or indirect or negative. In these types of studies, the variable of interest becomes the supervisory variable, and the characterization factors become associated variables. Relational studies look for an association, and there is no attempt to look for causality, not even statistical. The supervisory variable will mark the pace of the research, and this is the main variable in this type of study, while the associated variables, as their name indicates, are linked to the supervisor. Why is the term supervisor used? It is used because it is what will establish the research topic, because it is derived from the variable of interest of a descriptive study, and because the associated variables are going to be statistically analyzed with it, one by one. Relational studies can point to estimation (measuring the strength of the relationship), hypothesis testing (whether the association exists), and comparison (whether they are different or the same) (Supo & Zacarías, 2020).

The explanatory level can be divided into two subgroups: a) The observational, where there is no intervention, but a third variable called intervening must be incorporated, because, since causality is sought here, we have the dependent variable (which comes from the supervisor) and the independent (which comes from the associated); in this type of study, statistical causality is sought, and there is no intervention, manipulation, or control of variables. b) Experimental includes pre-experimental, quasi-experimental, and pure experimental studies. It must be understood that in these last two, a treatment or intervention must be applied to establish causality, not only statistical but also experimental (Hernández-Sampieri & Mendoza, 2018).

At the predictive level, the dependent variable becomes the variable to predict, and the independent variable becomes the predictor. These studies seek to predict, forecast or foresee and, to do so, statistical models are

used to establish these predictions. These studies are interventional and longitudinal, with control and manipulation of the variables, and produce predictive models (Rico & Gaytán, 2022).

Application studies seek to improve a situation or solve a problem. The variable to predict becomes endogenous, and the predictor variable becomes exogenous. In this context, what is sought is to evaluate, calibrate or improve a specific situation, considering studies with intervention (Vargas, 2009).

RESEARCH LEVEL, PURPOSES, AND OBJECTIVES

The taxonomy of Bloom et al. (1956) is used to establish research objectives; however, these are applicable in the field of the teaching–learning process but not in research; why is this? In the investigative field of science, taking into account the corresponding levels, the exploratory, descriptive, relational, explanatory, and predictive degrees are used to deepen knowledge, both qualitatively and quantitatively, while the objectives of Bloom et al (1956). are for the teaching–learning process. While the applicative degree in research is used to solve problems or to improve a process or procedure (Supo & Zacarías, 2020), in the taxonomy of Bloom et al. (1956), knowing is the first step and then understanding follows; therefore, there is no relationship between the Bloomian classification and the levels of research.

In research, basic or pure studies are carried out to obtain information, and this involves exploratory, descriptive, relational, explanatory, and predictive degrees, which implies an entire process where it is developed from qualitative to quantitative, from the exploration of concepts, terms, and subjects to predicting whether a certain phenomenon occurs under certain conditions or in a specific area. This is summarized in what is established as basic and applied science (Bunge, 1985).

Application and technological studies are those that aim to solve a problem; they are totally interventionist works, whereby, manipulating and controlling exogenous variables, they modify, improve, or solve a certain problem or situation that occurs in reality (Bunge, 1985).

There are seven levels of research, of which five are basic and two are applicational. Each one is linked to a specific purpose and, therefore, has a specific objective to express. The level of research is the degree of depth in the study, while the purpose is the analytical intention of the researcher, for which this intention is concretized when the general or main objective is expressed, according to the following table.

Table 1. Research levels, purposes, and objectives

Level	Purpose	Objective
Technological	Design	Design
Application	Application	Apply
Predictive	Prediction	Predict
Explanatory	Explanation	Explain
Relational	Relationship	Relate
Descriptive	Description	Describe
Exploratory	Exploration	Explore

Note: The purpose is a noun; the objective is a verb in infinity.

The purpose of a technological study is the design of an artifact or device that is usually carried out in a country's industry, for example, the manufacturing of a car or a spaceship, and that will have a considerable impact on human society. A prototype is built by a company or a company that can invest the resources it has in its design, development, manufacturing, and marketing. An example of this is the manufacture of blue Light-Emitting Diode (LED), invented by Nakamura et al. (Pérez, 2015), who had to conduct an investigation for 30 years, for which he received the Nobel Prize in Physics (SINC, 2014) by employing gallium nitride and revolutionizing lighting using blue LED.

The analytical intention of applicative inquiries is the resolution of a problem or the improvement in a process at a specific moment of reality within a society. It is usually carried out in university centers or by government entities that carry out research of this nature. The application is developed when there is secure knowledge that can allow this knowledge to be put into practice, intervening in the population to resolve a difficulty or improve complex situations within a community or global village (Bunge, La investigación científica. Su estrategia y filosofía, 1985). This does not mean that serendipity does not occur that changes things (Foster & Ellis, 2014).

Both technological and applied studies are based on basic research, and, for this reason, they require in-depth knowledge of the subject and the problem or issue that is presented.

Basic studies require time, patience, and tolerance because they cannot be developed overnight; one must accept that trial and error is the basis for continuing to inform oneself and investigate and continue on the path of science (Quirantes, 2018). Prediction is a purpose that involves establishing what phenomena may occur in the future, at a certain time, and what actions must be taken to minimize the risks or dangers underlying the event that could occur. However, the prediction must have a basis, either through data that can be extrapolated, as can occur in seismology or economics, or through an experiment that allows for the prediction to be tested, which can be performed by the researcher or by another person who has studied the same variables (Waljee et al., 2014).

Explanation is a purpose that attempts to establish causality within a phenomenon, for which it works with one or several antecedents, called independent variables, and another or other consequences or dependent variables. This type of study is extremely complex because it requires one to design an experiment or experiments that have to be repeated and reproduced to eliminate biases, intervening variables, and confounding variables, among others (Johannesson et al., 2023). When an experiment is designed, one is faced with an experimental explanatory investigation, where one will prove and/or verify that causality exists since it meets the Bradford Hill criteria: a) strength of association; b) consistency; c) specificity of the effect; d) temporal sequence; e) biological/social gradient; f) biological/social plausibility; g) coherence; h) experimentation; and i) reasoning by analogy (Cox, 2018; Höfler, 2005). Furthermore, it must be considered that the explanatory degree has an observational sublevel; that is, statistical causality can be established without conducting experiments, but this is only a first step to provide a basis to carry out the experimentation.

The relationship is a purpose where the aim is to establish a link between two variables, and causality is not sought; therefore, the name of these two variables must be different from those of the explanatory level. Relational studies can answer three questions: a) Is there a relationship between the two variables? b) How strong is the relationship between the two variables; c) What sense does that relationship have? Therefore, neither causality nor prediction can be established with only the association between variables (Lau & Kuziemsky, 2016; Russo, 2011). Although most studies are relational, this does not mean that causality can be established.

Description has a very important purpose because it is the first step in quantitative studies, having a single analytical variable, which means that the researcher is going to subject that variable to statistics, whether descriptive or inferential. The point is that descriptive studies feed relational studies, as they are the basis of a good statistical analysis that allows one to develop the association or relationship between the variables being investigated. There are a few types of descriptive studies, but the most common are developed in the field of health and are usually called epidemiological studies, that is, they are prevalence and incidence investigations. It must be added that in descriptive research, the variable must be called the variable of interest (Lans & van der Voordt, 2002).

Exploration is a purpose that ranges from the identification of a certain construct, which is usually called a category, to the diagnosis of said problem or topic of study, for which heuristics are used. The intermediate steps between phenomenology (identification) and heuristics (theoretically solving problems) are hermeneutics and constructivism. As the constructs are not measured, they will be identified and decomposed to determine their constituent elements. It is reiterated that they are called categories and subcategories, respectively (Tenny et al., 2023).

LEVELS, OBJECTIVES AND STUDY VARIABLES

There are a variety of classifications regarding the levels of research. In some cases, there is theoretical and practical research (Mejía, 2005); in others, there is basic and applied research (Bunge, 1985). There are also exploratory inquiries, in which phenomenological, hermeneutic, constructive, and heuristic studies are found, and quantitative inquiries, in which are descriptive, relational, explanatory, predictive, and applicational studies (Supo & Zacarías, 2020).

A research level is a grade or rank in investigative studies in science. It should be considered that these ranges mark the scope or depth of the investigations as a problem or topic of social, natural or technological relevance. In this sense, the aforementioned level must be taken into consideration to know what objective is going to be considered according to the title and problem formulated; and this must be aligned with the name given to the study variable, specifying that the verbs that are going to be used for the research objectives must have different nominations; this is carried out depending on the level of scientific inquiry. The variable of a descriptive study cannot be called the same as the variable of an applicative study; if a predictive study is carried out, it cannot be designated in the same way as when relational work is being carried out. Likewise, if the study is exploratory, we do not work with variables but with categories, which are not measured but rather decomposed and deconstructed, which is why statistics is used in quantitative research (Supo & Zacarías, 2020).

A research objective is one that specifies the purpose of the study and is written based on the analytical intention of the researcher. There are two large groups of scientific objectives: a) The objective to know, where exploratory, descriptive, relational, explanatory, and predictive studies are found; these studies group together the objectives that are written to gain a deep knowledge of the subject, and the objectives are at the service of basic studies. b) The objective to improve a process or solve a problem, where applicative and technological works are found, where the objectives are written in order to puzzle out certain problem, intervene and provide improvements to the situation or solve the problems presented. Every research objective has the following parts: a) analytical intention expressed as a verb; b) the variable or variables, which are in the line of research; c) the population, which is made up of the study units; and d) the space–time dimension, which indicates the place and time where the study will be carried out.

The variable is a property, characteristic, and singularity that an object, subject, fact, or construct has that can be observed, decomposed, enumerated, or measured, and it can acquire different values (Cuestas , 2009); hence, it can be defined conceptually or operationally (Arias, 2021). Depending on the attributes, the variables can be numerical, when they present the conditions of origin, distance, and order, or categorical, when they present the attributes of order and category (Azen & Walker, 2021). In addition, numerical variables are usually called quantitative or objective and can be discrete and continuous, while categorical variables can be designated as qualitative or subjective and can be ordinal and nominal (dichotomous and polytomous) (Cabezas et al., 2018). However, when it comes to the variables and levels of research, the variables will take different names due to the analytical intention of the researcher. One must be specific because the investigative purpose is different at each investigative level. In exploratory studies, the aim is not to measure but to decompose, which is why the variables are named categories. From descriptive studies, where quantitative studies begin, to technological works, the variables take different names due to the various analytical intentions that will be adopted (Supo & Zacarías, 2020). The following table shows the names of the variables depending on the research level and the objectives of the study.

Table 2. Levels, objectives, and names of variables.

Research level	General objective	Name of the variable(s)
Technological	Design	Endogenous variable
		Exogenous variable
Application	Assess	Endogenous variable
		Exogenous variable
Predictive	Predict	Variable to predict
		Predictor variable
Explanatory	Explain	Dependent variable
		Independent variable
Relational	Relate	Supervisory variable
		Associated variable
Descriptive	Describe	Variable of interest
Exploratory	Explore	Categories

Note: Variables are decomposed and measured; categories are decomposed.

Why does the name change? Since the analytical intention changes, the purposes are different, and, for this reason, they cannot be considered in the same way. In the field of medicine, is a bacterium the same as a virus? In the field of education, is strategy the same as the teaching–learning methodology? In the field of law, is

preventive detention equivalent to preliminary detention? In the field of engineering, is it the same to talk about columns and footings? In the field of accounting, could institutional budgets be confused with modified ones? Science, by its nature, is precise and exact in its terms and expressions. It must be taken into consideration that each purpose at a level or degree of research must nominate the variable(s) differently because the analytical intention is totally different. In that sense, it must be understood that the more precise and exact the term, the better the project and research report prepared. Just as professionals have clear and precise concepts in their field of activity, science must specify these aspects that should not be left to chance when it comes to carrying out scientific research.

The objectives shown in table 2 have been little studied because researchers have preferred to use taxonomies that correspond to other areas of study. In that sense, the study variable changes its designation as it passes from one level to another. The main variable, the one that marks the passage of the work, has to vary in name because the analytical intention has changed when moving from one level to another. In exploratory studies, the following objectives can be used, from a greater to lesser degree: diagnose, construct, interpret, and identify; in descriptive studies, they can be used following the same sense: verify, measure, and describe; in correlational research: measure, relate, and compare; in explanatory inquiries: verify, prove, and demonstrate; in predictive studies: foresee, forecast, and predict; and in technological and application research: design, improve, calibrate, and evaluate.

CONCLUSIONS

First: For technological and application studies, the main variable that is derived from the variable to be predicted is called endogenous, and the other variable is called exogenous. This is because these inquiries seek to design, solve problems, or improve processes.

Second: For predictive research, the main variable derived from the dependent variable is called the predicted, and the other variable is called the predictor. This is because these studies seek to foresee, forecast, and predict events or occurrences.

Third: For explanatory inquiries, the main variable derived from the supervisory variable is called dependent, and the other variable is called independent. This is because these studies look for causality; therefore, the studied phenomenon is verified, tested, and evidenced.

Fourth: For relational research, the main variable that is derived from the variable of interest is called supervisory and the other the associated. This is because what we are looking for is whether there is an association between both variables, how strong the relationship is, and what meaning it has.

Fifth: For descriptive works, the main variable derived from exploratory studies is called the variable of interest, and the other is called the characterization factor. These studies have a single analytical variable, and the researcher will apply statistics to it.

Sixth: In exploratory studies, we work with categories, which will be decomposed and cannot be measured or counted.

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