Chapter 2
An Overflight Over Research

Science has turned into the axis of contemporary culture. And, being the engine of technology, science ended up indirectly controlling the economy of developed countries. As a consequence, those who wish to obtain an adequate notion of modern society should study the mechanism of scientific production, as well as the structure and meaning of its products.

(Bunge 1980, p. 1)

This chapter presents the concepts of traditional science and Design Science. It further presents the concepts and types of research that relate to the theme of this book. Later, the types of research methods commonly used by authors in the field of management are presented, including the concept of the work method and the techniques used for gathering and analyzing data. In closing, considerations are provided regarding the trajectory of science and the forms and types of knowledge production.

According to Werneck (2006, p. 175), knowledge production can be understood as the "construction of universally accepted knowledge in a given historical time or as a process of learning of the subject". For knowledge production to be adequate, one critical factor for success is to guarantee that the right information is generated in the right format for the right user (Sun and Mushi 2010). Thiollent (1985) states that knowledge is produced based on the information obtained from two sources: (i) research authors, through their structuring of knowledge; and (ii) users who apply this knowledge in solving their real problems.

This chapter provides a short description of the traditional forms of producing knowledge. The focus is on the definition of science, particularly natural science, social science, and, briefly, artificial science, which is better approached later in the book. In addition, some concepts related to the research techniques and methods commonly used by researchers in the field of management are presented. Next, some topics are presented that are worthy of consideration regarding how knowledge that is termed "scientific" is produced.

A. Dresch et al., *Design Science Research*, DOI 10.1007/978-3-319-07374-3_2

2.1 Science

To Ander-Egg (1976, p. 15), science is "a collection of rational knowledge, certain or probable, methodically obtained, systematized and verifiable, that makes reference to objects of one same nature". Science has no subjectivity; the knowledge generated from it is reliable because it can be proved (Chalmers 1999; Popper 1979).

Traditionally, the goal of science has been to develop knowledge about what exists by means of discoveries and analyses of existing objects (Simon 1996). One of science's functions is to help understand systems by uncovering the principles that determine their characteristics, their inner workings, and the results they produce (Romme 2003).

Science, in turn, can be classified into factual science and formal science. Factual science explores, describes, explains, and predicts phenomena. It is validated when it provides some empirical evidence. Conversely, formal science does not depend on empirical confrontation (Hegenberg 1969).

Formal science encompasses subjects such as logic and mathematics—subjects that are not approached in this work. Factual science is traditionally divided into natural and social sciences. Natural sciences encompass disciplines such as physics, chemistry, and biology. Social sciences include subjects such as sociology, politics, economics, anthropology, and history (Hegenberg 1969).

Natural sciences are those whose goal is to understand complex phenomena. The knowledge they generate is descriptive and analytical. Knowledge production occurs by means of a search for knowledge that is general and valid to the formulation of hypotheses (Romme 2003). "A natural science is a body of knowledge regarding a class of beings—objects or phenomena—of the world: it occupies itself with its characteristics and properties; with how they behave and interact" (Simon 1996, p. 01).

The main research activities involving the natural sciences are to discover how things are and to justify the reasons for them being so. Natural science research should be faithful to the observed facts while also being capable of predicting future observations to some degree (March and Smith 1995).

With the establishment of the main concepts of the natural sciences, some concepts regarding the social sciences can be presented. Social sciences seek to describe, understand, and reflect on human beings and their actions (Romme 2003). Knowledge arises from what people think about some given object. In studies using the approach of the social sciences, the researcher usually has a certain proximity to his or her object of study (people). However, research conducted in the social sciences is usually questioned based on its subjectivity because one usually cannot easily demonstrate how rigorously a study has been conducted (Romme 2003).

Thiollent (1985) claims that the social sciences in Brazil suffer from a dichotomy because studies are usually developed based on either a more scientific trend (whose approach is usually more quantitative) or a more humanistic trend (which considers people as key factors who should be considered as such in conducting studies).

Both research works supported by the social sciences and those founded on the natural sciences have as their mission the search for the truth, and their goals are to describe, explain, and predict to advance the knowledge in a given area (Denyer et al. 2008). It is worth noting that in general, authors in the field of management seek to find solutions to given problems or to design and create artifacts that are applicable to the daily routine of professionals. Therefore, a study that describes or explains a given situation is not always sufficient for the advancement of knowledge in this sense.

The preceding observations demonstrate the need for a science that broadens the comprehension of what has been undertaken in management, i.e., a science that has the ability to prescribe solutions to real problems as well (Denyer et al. 2008; Pandza and Thorpe 2010; Simon 1996). For this reason, Design Science covers areas such as medicine and engineering in addition to management (Denyer et al. 2008; Simon 1996).

The concept of Design Science was first introduced by Herbert Simon in his book entitled "The Sciences of the Artificial", published in 1969. In this work, Simon (1996) presents the differences between natural science and Design Science, translated here as Project Science or the Science of the Artificial. Table 2.1 presents a synthesis of the main characteristics of the natural sciences, the social sciences, and Design Science.

It is worth highlighting that research work must be developed for science to move forward and scientific knowledge to advance, whether to confirm some theory or to propose solutions to specific problems. Therefore, the following section presents the main concepts and types of research considered relevant for this book.

Table 2.1 Synthesis—natural sciences, social sciences, and design science

Characteristic	Natural sciences	Social sciences	Design sciences
Purpose	To understand complex phenomena. To discover how things are and to justify why they are this way	To describe, understand, and reflect on human beings and their actions	To design; to produce systems that do not yet exist; to modify existing situations to achieve better results. Focus is on solutions
Research goal	To explore, describe, explain, and predict	To explore, describe, explain, and predict	To prescribe. Research is oriented toward solving problems
Examples of areas that usually employ each of these scientific paradigms	Physics, chemistry, biology	Anthropology, economics, politics, sociology, history	Medicine, engineering, management

Source Elaborated by the authors based on Hegenberg (1969), Denyer et al. (2008), March and Smith (1995), Romme (2003), and Simon (1996)

2.2 Research: A Proposal for Its Structuring

A research work can be defined as a systematic investigation whose central goal is usually the development or refinement of theories and, in some cases, the solution to problems (Gough et al. 2012). One may further add that the need for research work arises from the realization that adequate and systematized information to answer some given problem is missing (Saunders et al. 2012).

The reasons that motivate one to conduct research may come from a theoretical gap or from some demand in the practice. Research of a more theoretical character is usually called basic or pure research, and its main goal is to ensure scientific progress, with no concern regarding the use in practice of the knowledge it generates (Saunders et al. 2012). This type of research is commonly found in academia.

Research of a practical nature is referred to as applied research, and its main interest is that the results generated by it can be used in practice, helping professionals to solve problems that occur in their daily work (Saunders et al. 2012). One must note, however, that although a distinction between basic and applied research exists, they are not mutually exclusive (Saunders et al. 2012). One may advance scientific knowledge while at the same time supporting professionals in solving their problems.

It must be noted that, to carry out research work, particularly scientific research, one must follow certain procedures to guarantee the reliability of the results. Usually, knowledge is developed by applying traditional approaches, such as those of the natural and social sciences. Figure 2.1 presents a structure that seeks to illustrate some points that must be taken into consideration when conducting research work for the aim of producing scientific knowledge. To illustrate the relationships and dependencies between each of the steps that should be taken into consideration when conducting scientific research, the representation used here is based on Newton's pendulum.

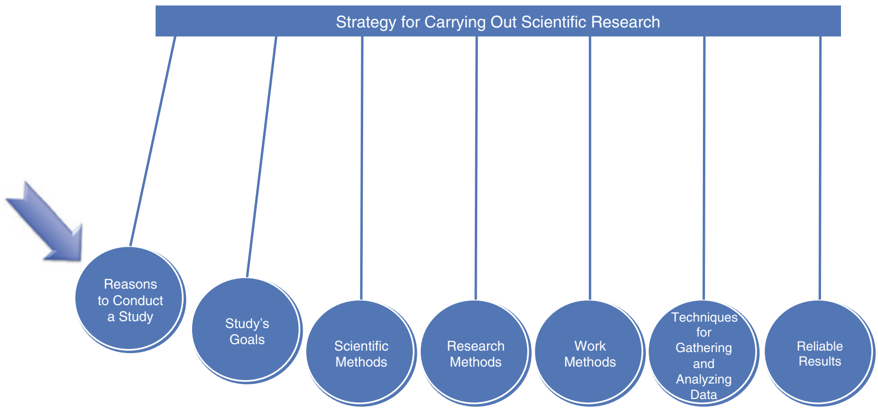


Fig. 2.1 Pendulum for conducting scientific research. *Source* Elaborated by the authors

Figure 2.1 seeks to unravel the structure that is traditionally used to produce scientific knowledge; this structure is based on the natural and social sciences. Next, to better understand what the pendulum is meant to represent, some of its concepts are described in detail.

The starting point in conducting scientific research is defining the reason for undertaking the investigation. This reason may be based on three main factors: (i) a new and interesting piece of information that the investigator wishes to share; (ii) an answer to some important issue; or (iii) an in-depth understanding of some phenomenon (Booth et al. 2008). Furthermore, the research process may be motivated by the following: (i) an observation of reality; or (ii) from the literature and previous knowledge by finding a gap that serves as a starting point for the study.

In addition to defining the starting point, the researcher must also define the goal he or she wishes to achieve with the investigation, i.e., whether one wishes to explore, describe, explain, or predict some behavior of the phenomenon being studied. To reach this goal, the researcher should select the scientific method that will guide his or her research work. The scientific method used will be directly influenced by the starting point of the study itself; i.e., whether the work starts with an observation of reality or by ascertaining a gap in the theory.

Once the research goal and the scientific approach that will guide the investigation have been defined, the researcher must now define the research method that is best suited for carrying out the study. Thus, researchers select the research method that is most adequate to their type of investigation. An adequate choice of research method aids the researcher in defining his or her own work method, which, in turn, ensures that the research work is carried out properly.

Elaboration of a work method is fundamental both to guide and support the researcher in carrying out his or her work and to guarantee that other researchers can use this method to replicate the study (Mentzer and Flint 1997). Note that, to elaborate a research method, one must choose and duly justify the techniques for gathering and analyzing the data to be used by the researcher.

One particularly noteworthy aspect is the need for the elements of the pendulum shown in Fig. 2.1 to be aligned. A lack of alignment between these elements may compromise or, more importantly, bias the results of the study. Another aspect of a misalignment is the difficulty of providing a systemic and systematic understanding of the adopted procedures and the way in which these procedures contribute to the study meeting its goals. Therefore, the researcher must know each element in the pendulum, select a strategy to address them, and justify his or her choices of methodology. An adequate stance and justification should serve as evidence of the care taken in carrying out the research work. Moreover, by means of this definition process, the research author can refine the methodological choices that provide support for the results of the research work being conducted.

In particular, one must explicitly present the procedures and their justifications in configuring the work method and the techniques for data gathering and analysis. However, to achieve this, some prior decisions are required with regards to both the configuration of the work method and the choice of techniques for gathering,

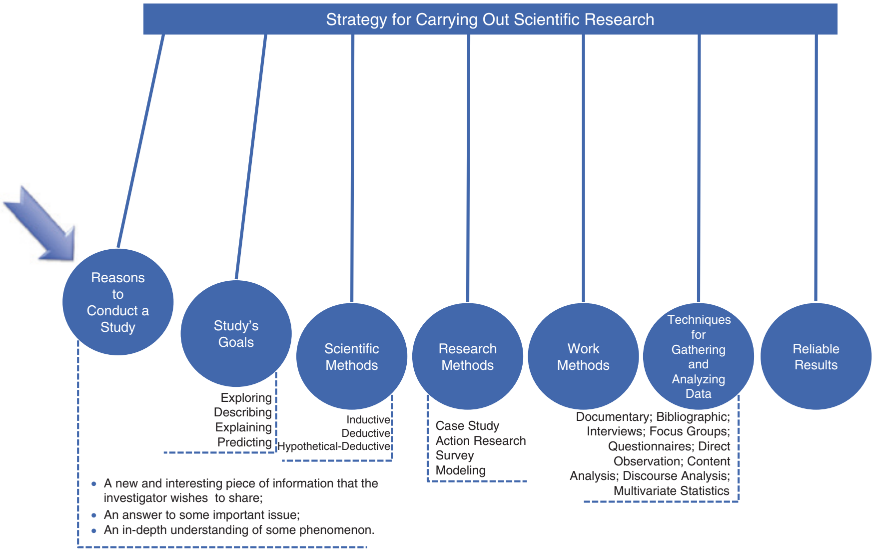


Fig. 2.2 Pendulum for carrying out scientific research. *Source* Elaborated by the authors

treating, and analyzing the data. Figure 2.2 synthesizes the main topics regarding the pendulum's elements that must be addressed.

In the following sections, the topics briefly highlighted in Fig. 2.1: Pendulum for conducting scientific research is presented in detail, and the limitations of using these approaches in carrying out research work in the field of management are shown. Note that the following sections do not aim to be exhaustive in regard to the scientific method, research method, work method, and so on; above all, the sections seek to address the main topics that are relevant to this book in particular.

2.3 Scientific Methods

This section presents the main scientific methods that guide the authors of studies in the field of management. The scientific method is a perspective on or premise about how knowledge is constructed. Therefore, a researcher must adopt a strategy and clearly state the scientific method that will serve as a guide in developing his or her research.

As one can observe in Fig. 2.3, researchers should take a stand regarding the scientific method that will guide the investigation shortly after defining the research goals. The researcher must also take into consideration his or her motivations to conduct the study. Later, the definition of the scientific method will guide the selection of the research method to be employed.

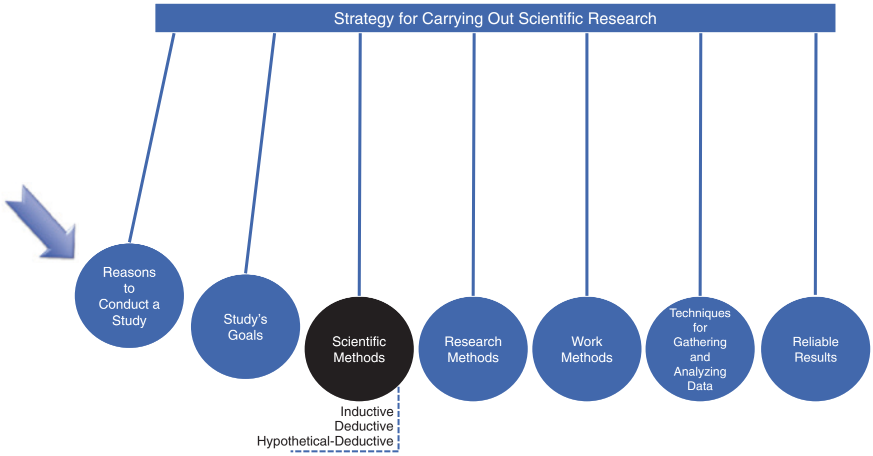


Fig. 2.3 Pendulum for conducting scientific research. Scientific methods *Source* Elaborated by the authors

2.3.1 Inductive Method

The inductive method is founded on premises and is stemming from the process of inferring an idea from previously ascertained or observed data (Saunders et al. 2012). According to Chalmers (1999), for an inductivist researcher, science is based on observation. Observation is the key point in constructing scientific knowledge. From the definition of propositions based on the scientist's observations, it is possible to generalize knowledge and propose a universal law; i.e., using particular and duly observed data, the scientist makes an inference regarding that which is being studied (Camerer 1985; Saunders et al. 2012).

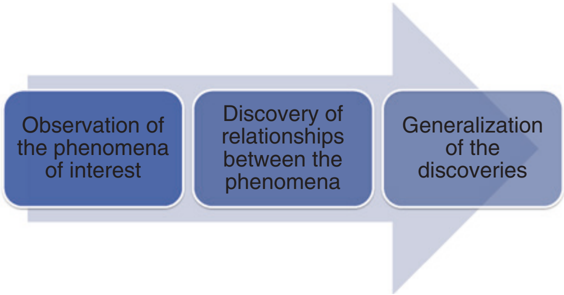
The scientist using the inductive method starts from the assumption that one can construct scientific knowledge by repeatedly observing a given object of study; i.e., based on these observations, one can propose theoretical foundations for the object of study (Chalmers 1999).

Therefore, from the inductivist's perspective, experience is fundamental in providing the foundations for knowledge. However, the observations should not suffer any interference from the researcher's personal opinions; the researcher should be as impartial as possible (Chalmers 1999). There are three basic steps in research work based on the inductive method. These steps are presented in Fig. 2.4.

However, extensive criticism has been made of the inductive method. One such criticism is the so-called "inductive leap", i.e., the route from "some" phenomena that have been observed to "all" phenomena, even those that have not been observed or those that cannot possibly be observed (Chalmers 1999; Eisenhardt 1989; Saunders et al. 2012).

The inductive method is commonly applied to research in management because studies in this area often spring from observations of reality. By observing facts,

Fig. 2.4 Steps comprising the inductive method. *Source* Elaborated by the authors, based on Chalmers (1999) and Saunders et al. (2012)



the researcher starts building conjectures that can contribute both to the solution to a practical problem and to supporting new theories. In the following, some concepts related to the deductive method are presented.

2.3.2 Deductive Method

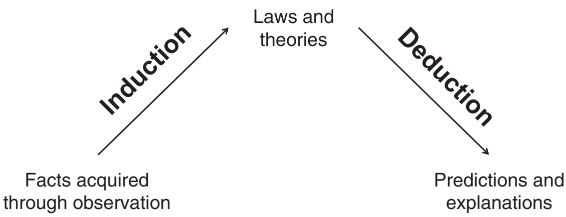
In the deductive method, the scientist starts from laws and theories to propose elements that may serve to explain or predict some given phenomena (Chalmers 1999). Chalmers (1999, p. 37) further claims that, in the deductive method, the "valid logical arguments are characterized by the fact that, if the argument's premise is true, then the conclusion should be true".

By using deduction, a scientist, knowing universal theories and laws, can build new knowledge based on this prior knowledge to explain and predict the behavior of the object of study. Figure 2.5 shows the process of knowledge production according to the approaches of induction and deduction.

The deductive method is characterized by the use of logic in constructing knowledge (Chalmers 1999). One significant difference between the inductive and deductive methods is that to develop the inductive method, one must necessarily start from the observation of phenomena, i.e., one must have an empirical basis. The deductive method starts from the proposition of laws and theories that encompass some given phenomenon, and knowledge is built from the definition of the premises and the analysis of the relationships between them.

One example of the application of the deductive method to studies in the field of management is the construction of conceptual models. The researcher starts from

Fig. 2.5 Production of knowledge according to the inductive and deductive approaches. *Source* Chalmers (1999, p. 29)



previous theoretical knowledge and, in a logical manner, proposes some possible relationships among the variables. Later, he or she seeks concrete data to confront the model with reality. Based on the results obtained, the researcher can explain or even predict some behaviors of the system being studied. In the following section, some concepts related to the hypothetical-deductive method are presented.

2.3.3 Hypothetical-Deductive Method

Popper (1979) is one of the main authors who question the inductive method, claiming that it cannot be recognized as an effective scientific method. He presents the hypothetical-deductive method as an attempt to develop a scientific method that is adequate for the search for truth. This method is characterized by identifying a problem based on previous knowledge and proposing and testing hypotheses that result in predictions and explanations (Shareef 2007).

Hypothetical-deductive logic is used by falsificationist scientists, who believe that there is more value in refuting an idea or theory than in confirming it (Chalmers 1999). To these scientists, it is when an idea is refuted that the evolution and advancement of science takes place. According to Chalmers (1999), even if one cannot confirm whether a theory is true, one can still say that it is the best available at the moment.

Popper (1979, p. 184) states that "whenever we start explaining a conjectural theory or law by means of a new conjectural theory of greater degree of universality, we discover more about the world (…). And whenever we manage to render one such theory false, we make an important discovery". This statement reflects the defense of falsificationism, through which one seeks to refute a hypothesis in the search for advancement of scientific knowledge.

The falsificationist believes that science is a collection of hypotheses that can be proposed and tested to describe or explain some given behavior of the object of study. Furthermore, to be recognized as scientific, a hypothesis must be falsifiable (Chalmers 1999). Put in simple terms, one can say that the hypothetical-deductive method consists of the four steps presented in Fig. 2.6.

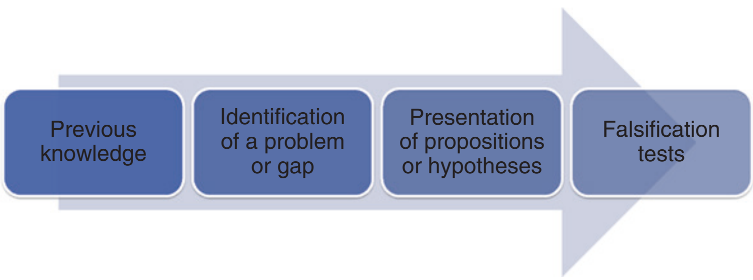


Fig. 2.6 Steps comprising the hypothetical-deductive method. *Source* Elaborated by the authors based on Chalmers (1999) and Shareef (2007)

In the hypothetical-deductive method, Popper (1979) suggests that a researcher should start from some previously constructed knowledge or some observed gap, propose new theories in the form of hypotheses or propositions, and put them to the test. Once tested, if these hypotheses are confirmed to be true, then they have been corroborated by previous experience. If the hypotheses yield a negative result, i.e., they are proved false in the tests, then they are refuted.

The hypothetical-deductive method can be found in works on management, for example, when the problem under investigation is related to assessing the quality of products and services. The researcher makes hypotheses and puts them to the test to verify whether the hypotheses are falsifiable or can be corroborated.

Finally, one could say that the scientific method or approach to be employed in an investigation should be chosen by in essence taking two factors into consideration. The first factor concerns the starting point that gave rise to the study, for example, whether the study originated in a theory gap, in a problem in practice, or directly from the observation of some phenomenon. The second factor that concerns the definition of the scientific method is the research goal, i.e., whether one wishes to explain, describe, explore, or predict.

These factors that address the choice of scientific method also concern the choice of research method to be employed. In view of the need to better understand the research methods that are commonly used in studies in the field of management, these research methods are described in detail in the following section.

2.4 Research Methods

This section addresses some of the foremost research methods used in studies related to management. Figure 2.7 illustrates how the chosen research method relates to other issues that should be taken into account by the researcher in defining his research strategy.

The importance of defining and justifying the research method is signified most of all by the fact that it helps the researcher ensure that his or her investigation will in fact provide an answer to the research problem. Furthermore, the adequate use of a research method also supports recognition of the investigation by the scientific community, providing evidence that the research work is reliable and valid for the field. Among the many existing methods, four have been selected as the most noteworthy; these methods are described next.

2.4.1 Case Study

According to Yin (2013), a case study is an investigation that is deemed empirical and that seeks a better understanding of a contemporary and usually complex phenomenon in its real context. Case studies are considered valuable because they

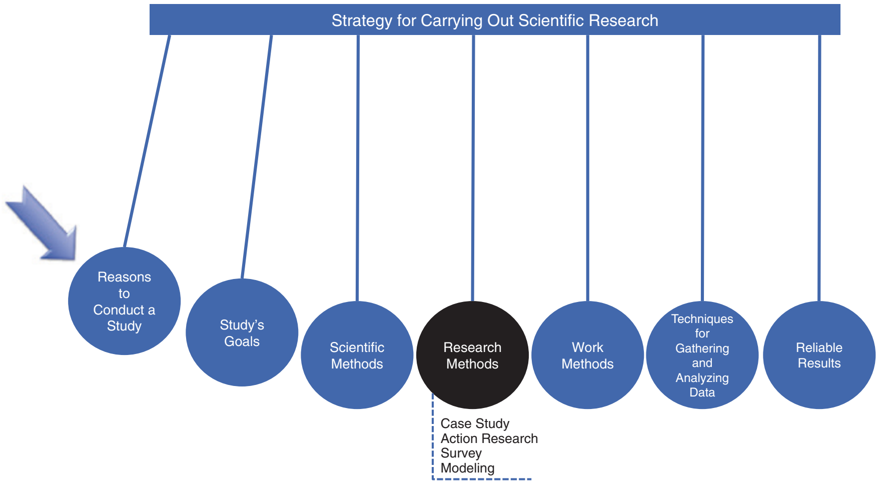


Fig. 2.7 Pendulum for the conduct of scientific research— research methods *Source* Elaborated by the authors

allow detailed descriptions of phenomena. They are normally based on a diverse set of data sources (Yin 2013).

The case study is particularly appropriate for the investigation of complex problems within the context in which they occur (Dubé and Paré 2003). Case studies ensure that the investigation and the understanding of the problem will both be in-depth (Dubé and Paré 2003).

It is characteristic of case studies to consist of a combination of data-gathering methods such as interviews, questionnaires, observations, and so on. This gathered evidence, which serves as a subsidy for the researcher, may be quantitative or qualitative (Eisenhardt 1989).

The foundation of case studies is the comparison of the collected data in which the researcher seeks to identify theoretical categories that can be used as a basis to propose of new theories (Eisenhardt 1989). Thus, according to Eisenhardt (1989), the main goals of a case study are (i) to describe a phenomenon; (ii) to test a theory; and (iii) to create a new theory.

In considering the general characteristics of case studies and their goals, one realizes their inductive nature. One of the reasons for this association is a study's starting point because a case study begins with the observation and analysis of real phenomena. Another reason for this association is that the scientific method assumes that theories will be generated, also one of the goals of case studies.

To meet the goals proposed by a case study, certain activities should be performed. The most important of these activities are listed in Fig. 2.8.

Note that case studies are essentially empirical and that the researcher acts as an observer and should not interfere in the study. Thus, to conduct a case study, the investigator must have great skill. In addition to not directly interfering in the

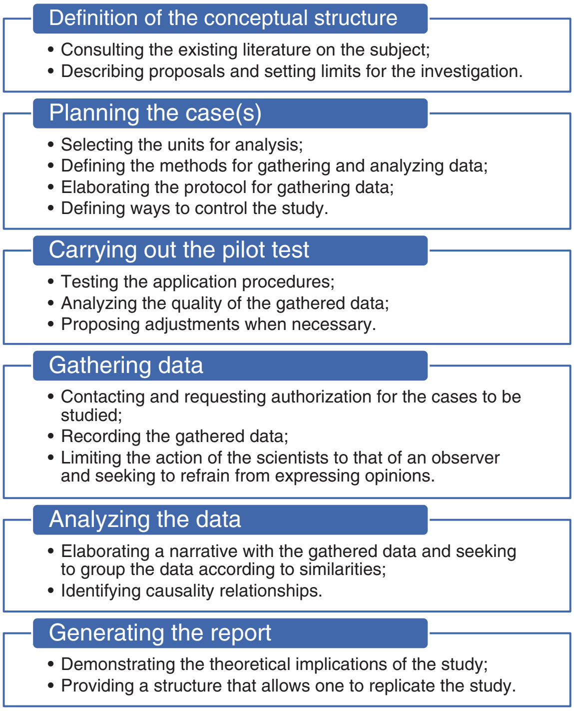


Fig. 2.8 Activities in a case study *Source* Elaborated by the authors based on Cauchick Miguel (2007, p. 221)

study, the researcher should carefully analyze the gathered data to verify possible behavioral patterns and to properly explain the phenomena (Ellram 1996).

Case studies are often questioned by the academic community in terms of rigor, and therefore, it is fundamental that the procedures used when carrying out case studies be made explicit, which grants additional credibility to the studies. Only with explicit procedures can readers of the study judge the solidity and adequacy of the applied methodology (Ellram 1996). Moreover, case studies tend to be exploratory, descriptive, and explanatory, which is typical of the natural and social sciences.

2.4.2 Action Research

The goals of action research are to solve or explain the problems that are found in a given system. It seeks to produce knowledge both for practice and theory. Similar to the case study, action research is exploratory, descriptive, and explanatory.

However, in contrast to the case study, the researcher in action research ceases being strictly an observer and takes an active role in the investigation. When this method is used, it is assumed that there is cooperation and involvement between the researcher and the members of the system being analyzed (Morandi et al. 2013). The researcher contributes to and interacts with the object of study (Benbasat et al. 1987; Thiollent 2009). The researcher has two roles when this research method is used: (i) he may be a participant in the implementation of a system; and, (ii) at the same time, he may wish to evaluate an intervention technique (Benbasat et al. 1987).

For a study to be classified as action research, there must in fact be an action by the members of the system being studied (Thiollent 2009). Furthermore, this action must not be trivial: it should be perceived as important to the studied context, thus justifying the reasons for the investigation (Thiollent 2009). The cycle for conducting action research, as well as its main activities, are presented in Fig. 2.9.

There are two aspects of the cycle proposed by Coughlan and Coughlan (2002) that are worth further elaboration. First, it is fundamental that the researcher understands the context in which the study will take place as well as the results that are expected at the end of it. Coughlan and Coughlan (2002) identify this element of understanding the context and goals as a prestage of the action research cycle but also one that is necessary for the study to develop well.

The second aspect to be noted is the monitoring stage. To Coughlan and Coughlan (2002), monitoring should be considered as a meta-stage because it should occur throughout the whole cycle established for conducting the action research.

Action research is fundamentally empirical and requires a qualitative approach. Moreover, at the study's conclusion, its results should be checked against the existing theoretical basis. Additionally, the implementation of the proposed solutions is mandatory to evaluate the results.

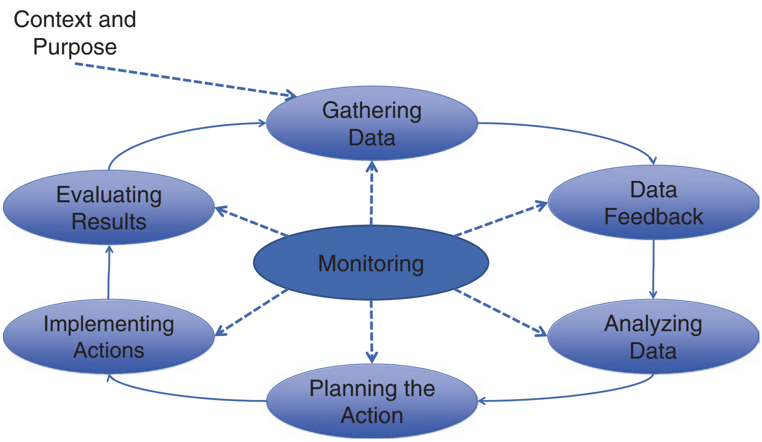


Fig. 2.9 Cycle for conducting action research. *Source* Coughlan and Coughlan (2002)

2.4.3 Survey

A study conducted using a survey approach aims to develop knowledge in a specific field. The investigation is conducted by means of gathering data and/or information to assess the behavior of people and/or the environment in which they act (Cauchick Miguel et al. 2012). Based on data gathering and analysis, the researcher can draw conclusions regarding the phenomenon or the population being studied.

A survey, similar to a case study or an action research, aims to explore, describe, and explain. However, depending on its goals, a survey may display some particular traits. Therefore, surveys are classified into three different groups: exploratory surveys, descriptive surveys, and explanatory surveys (Cauchick Miguel et al. 2012; Forza 2002). Table 2.2 presents the main characteristics of each type of survey.

Table 2.2 Characteristics of each type of survey

Element	Type of survey		
	Exploratory	Descriptive	Explanatory
Unit(s) of analysis	Clearly defined	Clearly defined and appropriate to the investigation's questions and hypotheses	Clearly defined and appropriate to the investigation's hypotheses
Respondents	Representative of the unit of analysis	Representative of the unit of analysis	Representative of the unit of analysis
Research hypotheses	Not necessary	Clearly defined questions	Clearly established hypotheses associated with the theory
Sample selection criteria	By approximation	Explicit, with logical argument; choice based on alternatives	Explicit, with logical argument; choice based on alternatives
Representativeness of sample	Not necessary	Systematic and with a well-defined purpose; random selection	Systematic and with a well-defined purpose; random selection
Sample size	Sufficient to include part of the phenomenon of interest	Sufficient to represent the population of interest and perform statistical tests	Sufficient to represent the population of interest and perform statistical tests
Questionnaire pre-test	Conducted with part of the sample	Conducted with a considerable part of the sample	Conducted with a considerable part of the sample
Return rate	No minimum	More than 50 % of the population under investigation	More than 50 % of the population under investigation
Use of other methods for gathering data	Multiple methods	Not necessary	Multiple methods

Source Forza (2002, p. 188)

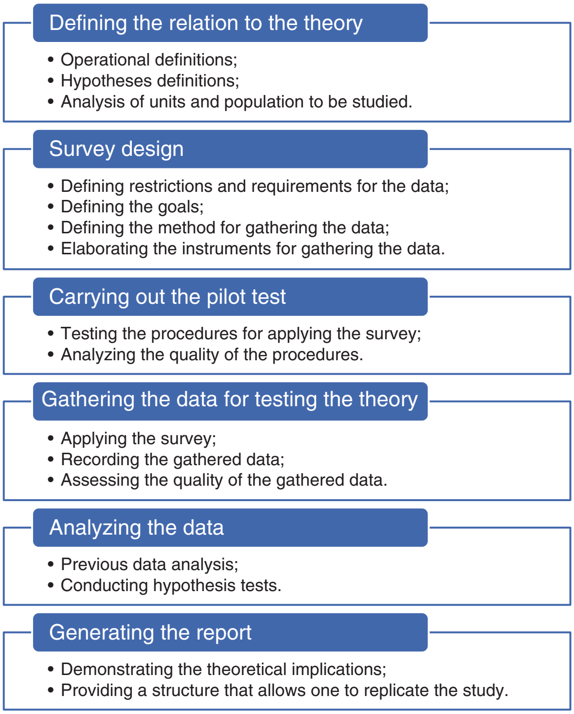


Fig. 2.10 Activities in a survey for theory testing. *Source* Elaborated by the authors based on Forza (2002)

However, independent of the research goal and the type of survey to be conducted, certain steps must be followed. These steps most of all seek to ensure that the research is rigorous. Based on Cauchick Miguel et al. (2012), these steps are described in Fig. 2.10.

Note that a survey, in contrast to a case study or action research, uses a quantitative approach. Moreover, one of the goals of studies conducted through surveys is to generate reliable data that allow for a robust statistical analysis.

Cauchick Miguel et al. (2012) claim that surveys may provide significant contributions to studies in the field of operations management. This contribution seems even more interesting when the study's goal is to develop a descriptive perspective of a given phenomenon or when one wishes to test existing theories (Cauchick Miguel et al. 2012).

2.4.4 Modeling

Modeling is a research method that supports investigators in better understanding problems. Models are simplified representations of reality that allow researchers to better comprehend the environment being studied (Neto and Pureza 2012; Pidd 1998). In the field of management, modeling is most commonly applied to operational research.

Table 2.3 Hard versus soft approaches

Characteristics	Hard approaches	Soft approaches
Problem definition	Seen as direct, unitary	Seen as problematic, pluralistic
Organization	Tacitly admitted	Requires negotiation
Model	A representation of the real world	A way to generate debate and insight about the real world
Result	A product or recommendation	Progress through learning

Source Pidd (1998, p. 115)

The concept of modeling is quite broad, and it is often used in an all-encompassing manner in studies in the field of management. According to Pidd (1998), modeling can be separated into two approaches: hard and soft. One should note that these two approaches are not mutually exclusive and may in fact be complementary to one another (Rodrigues 2006). Table 2.3 presents some of the differences that can be observed between these approaches.

In Table 2.3, one can observe that the hard approach to modeling is primarily based on mathematical grounds (Pidd 1998). This approach is best used when the problem to be studied is well structured and understood (Pidd 1998).

The soft approach to modeling considers the entire context of a problem. For this reason, the soft approach is most often used when there is a need to consider behavioral and contextual issues (Pidd 1998). Both the hard and soft approaches present several techniques for their implementation.

Some techniques of the hard approach, which can also be applied to research in the field of management, include linear programming, computational simulation, heuristics, and queue theory, among others (Rodrigues 2006). It should be noted that these techniques related to the hard approach are usually used when the researcher is seeking to optimize systems (Pidd 1998).

Among the hard modeling techniques, computational simulation stands out. Computational simulation is especially important for the study of situations in which considerably complex transformations take place frequently (Pidd 1998). The simulation technique is especially relevant when one seeks to explore or experiment with a given situation.

The use of computational simulation is interesting because it allows the investigator to find answers at a relatively low cost and very safely and swiftly, in comparison with experiments in a real context (Pidd 1998). Moreover, the usage of computational simulation as a modeling technique becomes especially interesting when the problems being studied are dynamic, interactive, and complicated (Pidd 1998).

The soft approach, in turn, also includes certain techniques that are directly associated with it, including, for example, the Soft System Methodology (SSM), which was first proposed by Checkland (1981) to address complex situations in which the hard approach proved insufficient (Pidd 1998). One characteristic of the SSM as an approach to modeling is that it emphasizes the learning process generated during its application (Pidd 1998).

Furthermore, the SSM allows one to create models of complex situations (Pidd 1998). These models can serve as a reference both in understanding and supporting the solutions to problems. One should note that use of the SSM is strongly related to the concept of Systemic Thought (Andrade et al. 2006).

Systemic Thought, in turn, is the basis for the construction of the Systemic Method, whose purpose is to support the solutions to complex problems and to generate learning regarding the problems and the situations in which they occur (Andrade et al. 2006). Systemic Thought can be perceived as an approach to be used when one wishes to see the whole because it allows the interrelations between the parts of a system to be analyzed instead of only analyzing events (Senge 1990). These characteristics of Systemic Thought certainly contribute to the modeling of complex problems targeted by researchers.

Having presented the foremost research methods used by authors of studies in the field of management, the next section presents some of the concepts and premises that guide the definition of the work method. The work method provides the organization of the activities that the researcher will conduct, and it also details and defines the techniques that will be used in carrying out each activity.

2.5 Work Method

The work method defines the sequence of logical steps that the researcher will follow to reach the goals he or she set for the study. It is essential that the work method is very well structured and that it is properly followed to ensure a study's later replicability (Mentzer and Flint 1997). A properly defined work method also provides greater clarity and transparency in the research process, which helps its validity to be recognized by other researchers.

In the work method, the researcher should describe the chosen research method by using the defined scientific method as a foundation. Moreover, to construct the work method, the researcher should define the techniques that will be used to gather and analyze the data that will be used to execute the study. In addition, this definition of the techniques to be used will support the researcher when defining the procedures to be used in triangulation. In addition to explicitly selecting the techniques for gathering and analyzing the data, the investigator must provide the reasons that motivated these choices. In fact, all of the decisions made by the researcher in the course of the study must be duly justified. The relationships between these many choices faced by the researcher are visualized in Fig. 2.11.

Research methods are generic methodological guidelines. The choice of a research method depends on a previous stand taken by the researcher regarding the scientific method. However, research methods must have a degree of generality to be accepted as valid procedures by the scientific community. The researcher must adapt and contextualize the research method to the specific investigation to be conducted.

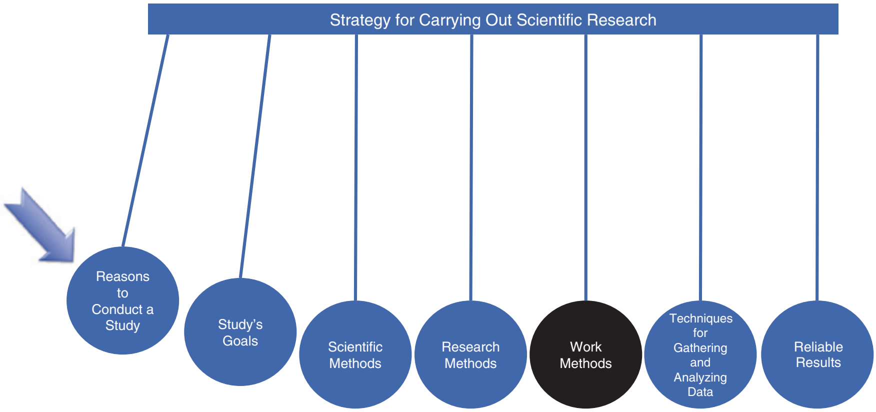


Fig. 2.11 Pendulum for conducting scientific research—work method. *Source* Elaborated by the authors

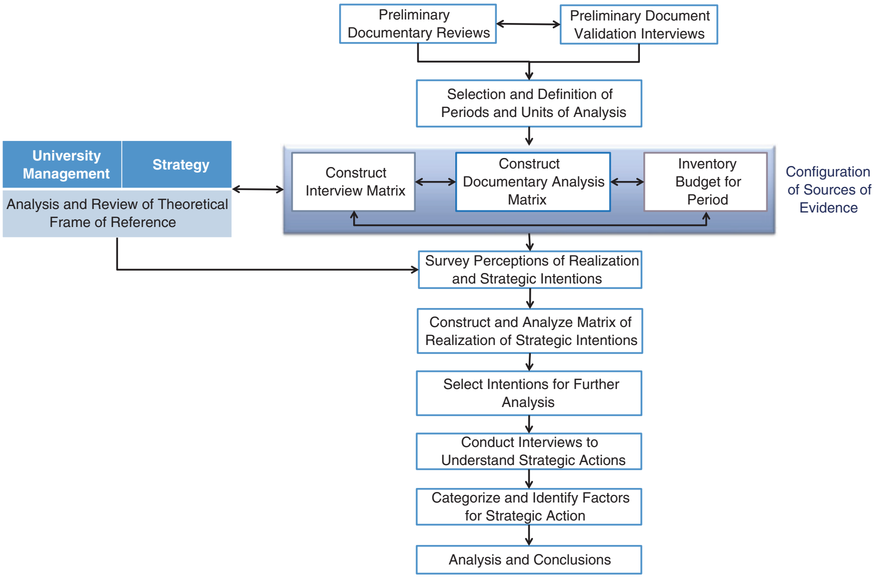


Fig. 2.12 Example of work method. *Source* Lacerda et al. (2014, p. 64)

Therefore, the work method will reveal the chosen research method. In a case where a study articulates several research methods, they are described through the work method. Specifically, the work method should present, in detail, the activities (steps) to be taken throughout the entire research enterprise. In addition to presenting these steps, the researcher must reveal and justify his or her reason for performing these activities and, most importantly, describe how these activities contribute to the researcher's conclusions, thereby increasing their reliability.

In the work method, the techniques for gathering and analyzing the data should be defined. For example, if the researcher intends to use more than one technique for gathering data, he or she must explicitly describe whether such techniques will be used in sequence or in parallel. The researcher must describe the analysis techniques used in connection with each data-gathering technique, i.e., that the work method provides and justifies the procedures for triangulation (of theories, methods, techniques, and data) (Mangan et al. 2004). By means of an illustration, Fig. 2.12 presents a work method that is revealed from a case study research method.

Based on the understanding of the concept of the work method, we now examine some research techniques that support researchers in undertaking their investigations. These research techniques are presented in the next section and are split into two parts. The first refers to techniques for gathering data, whereas the second part refers to techniques for analyzing data.

2.6 Techniques for Gathering and Analyzing Data

Techniques for gathering and analyzing data are fundamental to ensure the operationalization of the research methods and the work method defined by the researcher. Before selecting a technique to be used in conducting an investigation, a researcher must carefully consider the data being sought, including how it can be found, when it can be found, and who can actually find it.

In addition, the choice of techniques for gathering and analyzing data should be properly justified by the researcher. To justify this choice, the researcher must keep in mind that (i) the definition of how the data analysis will be conducted may determine the limits of data gathering and even the dissemination of the results and that (ii) the data analysis and interpretation are significant contributions of his or her research work (Amaratunga et al. 2002).

Furthermore, it is fundamental that the researcher, in defining the techniques for gathering and analyzing the data to be used in the study, takes into consideration the scientific community with whom the study is supposed to establish a dialog. Thus, the researcher must respect the criteria and parameters used by the scientific community regarding the procedures for gathering and analyzing data (Fig. 2.13).

The techniques selected for presentation in this section include some that are commonly employed in studies undertaken in the field of management. The techniques for gathering and analyzing data encompass a series of instruments that are used by researchers in carrying out the activities planned for their investigations. The gathering and analysis of data can be performed in several ways according to the goals of the study being conducted as well as the research method being used.

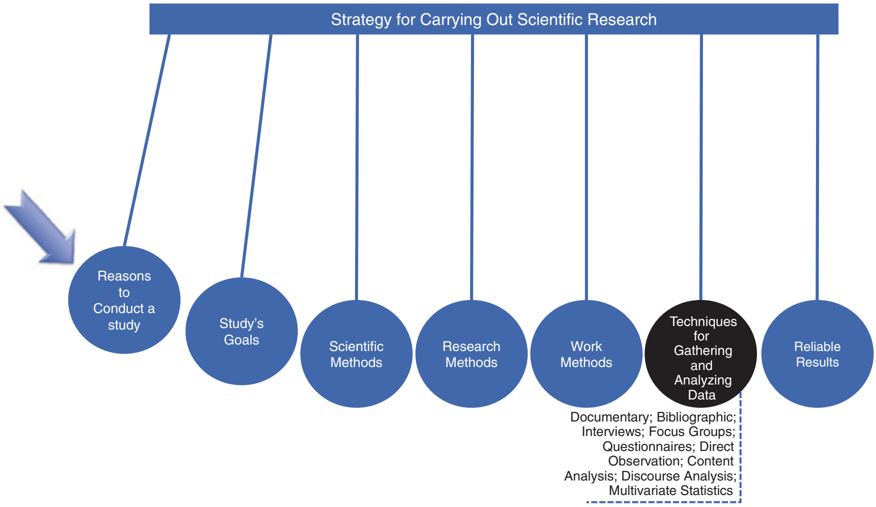


Fig. 2.13 Pendulum for conducting scientific research—techniques for gathering and analyzing data. *Source* Elaborated by the authors

Table 2.4 Techniques for gathering and analyzing data

Objective	Techniques
Data gathering	Documentary Bibliographic Interviews Focus groups Questionnaires Direct observation
Data analysis	Content analysis Discourse analysis Multivariate statistics

Source Elaborated by the authors

Next, some techniques for gathering and analyzing data that are recommended for the operationalization of the previously discussed research methods are presented. The goal of this presentation is not to detail the application of each technique but rather to provide an overview of the theme by noting the techniques that are usually applied in studies in the field of management. Table 2.4 presents the main techniques to be presented.

The foremost techniques for gathering data that are normally applied in studies in the field of management are presented next. This is a fundamental step in the research work and should be well planned and rigorously carried out to avoid biased or untrue conclusions.

One technique that can be used for gathering data is the documentary technique. Such a data-gathering technique is usually the first necessary step in the operationalization of a study because it allows the researcher to collect previous information on the topics to be studied (Saunders et al. 2012).

These documents may or may not be textual (pictures, audio or video recordings, etc.), and they may be classified as primary or secondary sources. Primary documents are those that are compiled or produced by the researcher him or herself. Secondary sources are those that have been transcribed from primary sources or, alternatively, recordings, pictures, and so on that have been used by the author but were produced by other people (Saunders et al. 2012).

Another technique used to gather data is the bibliographic technique. The goal of this technique is to provide to the researcher what has previously been developed on a given theme. Bibliographic research allows that which has been said or written about a given subject to be studied again under a new light, allowing the possibility for new discoveries on the subject (Saunders et al. 2012). To use this data-gathering technique, the researcher may use books, articles in scientific periodicals, and conference proceedings, among others.

A third technique for gathering data is the interview. The interview is a procedure that is often used to gather data, and its goal is to investigate a given situation or diagnose given problems. Interviews may be classified into two types (Dicicco-Bloom and Crabtree 2006):

- Standardized/structured: in this case, the interviewer defines and follows a pre-established script. The interviewer cannot adapt/modify the questions in response to the situation;
- Not standardized/not structured: the interviewee may develop the situations as he sees fit. Thus, the subjects may be explored in a broader manner. Questions are open and may be answered in an informal conversation.

Among the advantages of the interview, the foremost is that it is a flexible instrument through which questions may be rephrased to provide greater understanding of the gathered data (Saunders et al. 2012). When an interview is conducted in person, in addition to the verbal answers of the interviewee, it is also possible to observe his or her attitude toward the questions. Furthermore, the interview represents an opportunity to gather information that is not normally found in bibliographic sources.

Nevertheless, the interview also has some disadvantages, including possible difficulties in communication between the interviewer and the interviewee and difficulties interpreting questions and answers (Saunders et al. 2012). Another disadvantage is that during the interview, a bias may be introduced by the interviewer/researcher. Moreover, the interviewee may withhold important information, which the researcher has no control over.

Another way to conduct data gathering is by creating a focus group. The focus group has a qualitative nature and aims to understand the considerations made by a group of people after an experience, idea, or event (Plummer-D'amato 2008). The focus group can be perceived as an in-depth interview that occurs in groups with structured sessions that contemplate the proposal, the size, the components, and the procedure for conducting the group (Saunders et al. 2012).

According to Plummer-D'Amato (2008), one particular trait of the focus group in comparison with the classical interview is that it allows the participants to interact, and this interaction may allow some to influence the answers of others. To conduct a focus group, the researcher must first define (i) the members who will participate in the focus group; (ii) the content of the interviews; and (iii) how the moderator will interact with the participants, among others (Saunders et al. 2012).

When conducting a focus group, a researcher should pay attention to the time of each activity, making explicit and clear what should be done and what goal the researcher wishes to attain with the activity (Saunders et al. 2012). Despite being a technique for gathering data, the use of a focus group assumes that an in-depth analysis of what is obtained from its proceedings will be conducted. The analysis of a focus group's results should be performed systematically, focusing on the focus group's objectives (Saunders et al. 2012).

Another technique for gathering data is the questionnaire, which consists of the application of a series of questions to a respondent. It is recommended that the interviewee answers the questionnaire in writing, which should facilitate the later analysis of the answers by the researcher (Saunders et al. 2012).

Depending on the research goal and the technique to be used to later analyze the gathered data, the researcher may choose different forms of questions in a questionnaire. The types of questions can normally be classified into three categories: (i) open questions, which are used in investigations that aim for greater depth and precision. However, the interpretation and analysis of the results is more complex; (ii) closed questions, which present alternatives to the respondent and restrict their answers but at the same time eases the analysis of the data because of the objectivity involved; and (iii) multiple-choice questions, which are also closed questions, but which present more alternative answers to the respondents. Multiple-choice questions may elicit more detailed information about the object being studied (Saunders et al. 2012).

Finally, another option for data gathering is direct observation. This technique allows the researcher to identify some given traits of the phenomenon or system being studied that often go unnoticed by the individuals who are part of the system. Therefore, this technique is more suited for some studies even when compared with general interviews or questionnaires.

However, to be scientifically valid, the observations must be conducted in the context of a plan that is duly elaborated and followed by the investigator (Saunders et al. 2012). These observations may be performed in a structured or unstructured manner; the observer may or may not be an active participant; the observations may be performed individually or by a team; and, finally, the observations may be conducted in a real or controlled (i.e., laboratory) environment (Ander-Egg 1976; Saunders et al. 2012).

Some techniques for data analysis are presented next. It is in this phase that the researcher interprets the gathered data to obtain the results of the study.

One technique that can be used to analyze data is content analysis. According to Bardin (1993, p. 38), content analysis may be understood as "a collection of communication analysis techniques, which uses systematic and objective procedures for the description of messages' contents". This type of analysis aims to infer conclusions regarding the content of messages delivered by someone. The inference may answer (i) what caused the message, i.e., what led the person to emit this type of message, or (ii) what the consequences of this message are, i.e., what effects that the message will have (Bardin 1993).

In addition, content analysis is present in two important issues for scientific research: the rigor of objectivity and subjectivity (Capelle et al. 2003). Therefore, content analysis, in seeking to reduce the subjectivity commonly found in qualitative studies, elaborates both quantitative and qualitative indicators that may support the researcher in understanding and comprehending the messages being communicated (Capelle et al. 2003). Based on this understanding and deduction, the researcher is able to infer results about the object of study (Capelle et al. 2003).

It is worth noting that content analysis has two main functions: (i) a heuristic function and (ii) an administrative proof function. The objective of the heuristic function is to make research more robust, increasing the odds of the researcher making discoveries. Furthermore, the heuristic function aims to foster the conception of hypotheses when the investigation seeks content that has been little explored in other studies (Bardin 1993).

The objective of the administrative proof function, in turn, is to serve as proof in the confirmation of hypotheses (Bardin 1993). These hypotheses may be either in the form of questions or in the form of provisional statements (Bardin 1993). In addition, to meet its goals, content analysis must be systematized into three large phases, as presented in Fig. 2.14.

It is worth noting that although the phases presented in Fig. 2.14, content analysis itself is influenced by the goals of the study being conducted. Moreover, the research problem and the researcher's previous knowledge also influence how the

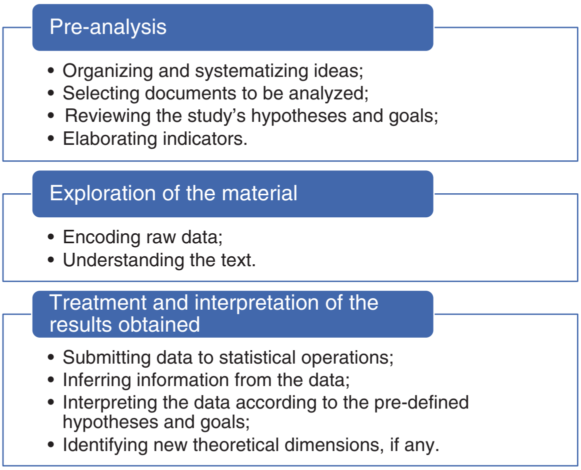
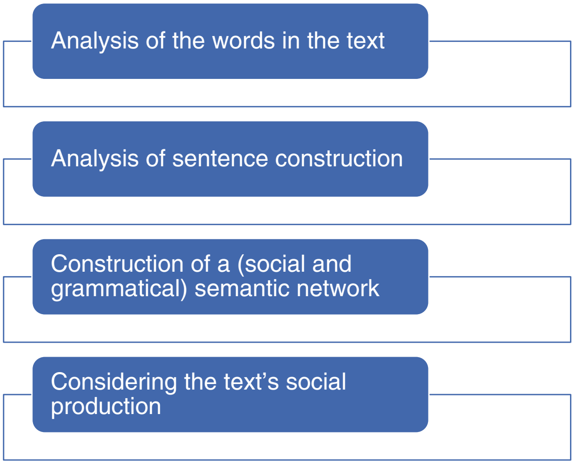


Fig. 2.14 Phases of content analysis. *Source* Elaborated by the authors based on Capelle et al. (2003)

Fig. 2.15 Steps in discourse analysis. *Source* Elaborated by the authors based on Capelle et al. (2003)



content analysis is carried out (Capelle et al. 2003). The researcher must therefore make decisions while executing this technique to obtain the best possible result in the analysis of his or her study's data.

Another technique that can be used to analyze data is referred to as discourse analysis. According to Minayo (1996), discourse analysis aims to understand the mechanisms that are seemingly hidden beneath the language. Moreover, discourse analysis is not a technique that seeks to describe or explain some phenomenon but rather to establish a criticism of something that already exists (Minayo 1996). Figure 2.15 presents the macro steps that are necessary to carry out discourse analysis.

It must be stressed that discourse analysis does not aim to understand or interpret what a text means but rather to understand how the text works in a given social and historical context (Capelle et al. 2003; Caregnato and Mutti 2006); i.e., discourse analysis addresses the meaning of the text and how it can influence a given environment or context (Caregnato and Mutti 2006).

Finally, the third technique that can be used to analyze data is multivariate statistics. The analysis of quantitative data by means of multivariate statistics is used to generate useful information from previously gathered data. The main purpose of this information is to guide the decision-making process and generate knowledge about a given problem or situation (Hair Jr et al. 2009).

According to Hair Jr et al. (2009, p. 23), "multivariate analysis refers to all statistical techniques that simultaneously analyze multiple measures of individuals or objects of investigation". However, for the researcher to successfully use multivariate analysis, certain directives must be taken into consideration. These directives are presented in Fig. 2.16.

Hair Jr et al. (2009) also state that there are several techniques that may be used to carry out multivariate analysis. It is not the present text's goal to describe each of these techniques in detail; nonetheless, among the foremost techniques, one

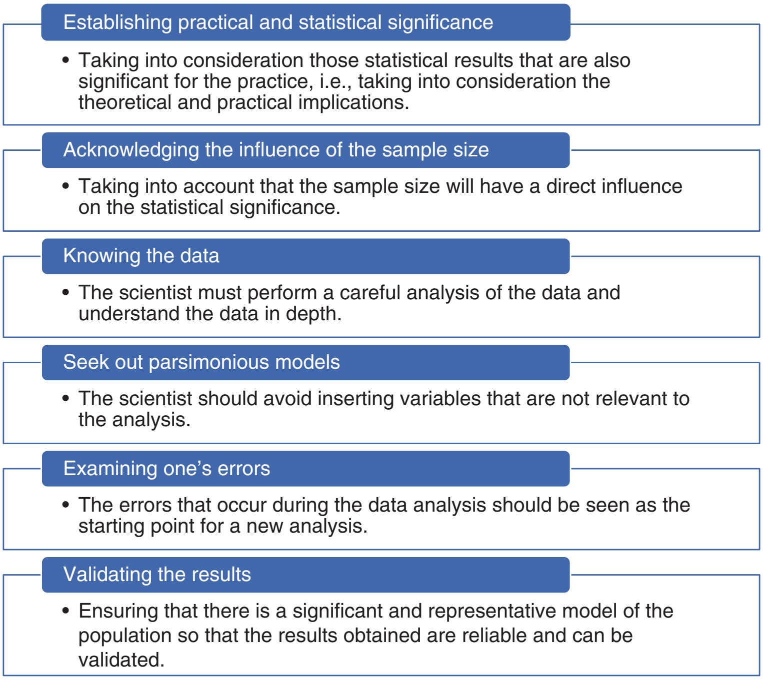


Fig. 2.16 Directives for the proper application of multivariate analysis. *Source* Elaborated by the authors based on Hair Jr et al. (2009)

may highlight multiple regressions and multiple correlations, multivariate analysis of variances and covariances, conjoint analysis, structural equation modeling, and confirmatory factor analysis (Hair Jr et al. 2009).

2.7 A Contextualization of Scientific Evolution

The preceding sections presented concepts related to scientific methods, research methods, and techniques for gathering and analyzing data. It is well known that these elements are fundamental to conducting research work. However, it is also important to consider how research works relate to one another and advance over time, which directly affects the trajectory of knowledge.

It is fundamental that the researcher considers how his or her work relates to other works over time and also that the researcher understands how research works affect the trajectory of science. Some authors have shown particular concern with science's trajectory rather than only on the research work itself.

This section presents a succinct description of science's trajectory from the perspectives of different authors. This description covers the main concepts of induction, deduction, the scientific paradigm (Kuhn's view), research programs (Lakatos' view), and anarchism (in light of Feyerabend).

2.7.1 The Origins of Knowledge Production: Induction and Deduction

When discussing the trajectory of science, it is interesting to start from what is known as “Hume’s Problem”, which can be described as follows:

(a) “All reasoning that refers to facts seems to be founded in a cause-and-effect relationship” (Hume 1999, p. 31);
(b) The cause-and-effect relationship is not known ‘a priori’;
(c) How is it possible to justify a passage that repeats itself several times as a universal reasoning and assertion?
(d) How can one justify the passage of temporal historical experience into causal reasoning?
(e) A causal relationship is not established by reasoning but rather “derives completely from habit and experience” (Hume 1999, p. 54);
(f) Hume’s basic conclusion is that ‘there is no rational justification for scientific laws’.

Therefore, Hume, the great skeptic of the eighteenth century, perceives the method in natural sciences as an effect-cause-effect logic (causal nexus). However, this causal nexus is considered in the context of induction and of a nonrational perspective. For the advocates of induction, the path toward scientific knowledge consists of proposing general conclusions based on a systematic collection of specific observations. This type of posture, which first appeared following Hume’s thinking, is historically linked to a scientific tradition that is connected to empiricism and induction—the so-called empirical science.

It is worth noting the issue of language, which has been well developed within the inductive framework. One of the relevant points in the perspective of induction consists of making the meaning of each word clear; i.e., one must introduce as much conceptual precision as possible.

The relationship signifier/signified implies the possibility of a given word—a signifier—being understood in several different ways—the signifieds. For example, the meaning of the words (signifiers) mass, velocity, and acceleration are completely different if the proposed theory concerns classical or quantum mechanics. Therefore, for a scientific theory to be developed with the required precision, it is fundamental to define the different signifieds/signifiers that compose the theory in the clearest manner possible.

Hume’s thinking was taken up again years later by Karl Popper. Popper starts from Hume, which is made clear in the following statement: “I approached the induction problem through Hume, whose statement that induction cannot be logically justified I considered to be correct” (Popper 2005, p. 72).

Popper develops his work criticizing the central idea of the theory proposed by Hume based on “repetition based on similarity” (Popper 1963, p. 27). According to Popper: “Independently of how many white swans cases we may observe, this does not justify the conclusion that all swans are white” (Popper 2005, p. 28).

This criticism of induction made by Popper is metaphorically depicted by Bertrand Russell, who describes the famous case of the "inductivist turkey". A given generic turkey learned that it was fed every day at 9:00 in the morning, and, because it was a "classic inductivist turkey", it drew (jumped to) certain conclusions: "I am always fed at 9:00 in the morning". However, its hypothesis revealed itself melancholically wrong when, on Christmas Eve, instead of being fed at 9:00 in the morning, it was beheaded. Therefore, an inductive inference with true premises (the turkey was fed everyday at 9:00 in the morning) led to a false conclusion (the turkey will always be fed, everyday, at 9:00 o'clock in the morning) (Chalmers 1999).

Popper's (1963) thoughts on 'Hume's problem' led the author to replace Hume's proposal with the perspective in which the scientist, instead of passively expecting that repetitions impose regularities on the world, actively seeks to impose regularities on it himself. This idea gave birth to Popper's Theory, which is based on a process of trial and error. According to this perspective, theories must be constructed based on a systematic logic of conjecture and refutation. Finally, an alternative method to induction for observing the causal nexus appears: the deductive perspective.

According to Popper, what takes place in science is a process that allows one to comprehend why our attempts to impose interpretations on the world logically came before similarities were observed (Popper 1963). Popper thus argues that scientific theories were not constructed from a composition of successive observations, as proposed by induction's advocates. In truth, theories and the construction of knowledge are conjectures that, if presented in a daring form and according to certain logical criteria, might be refuted if they do not properly fit empirical observations (Popper 1963). A necessary conclusion from Popper's proposal is that it must be possible to empirically refute theoretical conjectures (hypotheses).

This process of developing Popper's ideas leads to a discussion of the logical criteria required to develop a scientific study. In this sense, one must understand the so-called demarcation problem and falsifiability as a criterion of demarcation. Popper calls the "criterion of demarcation" the "problem of establishing a criterion that enables us to distinguish between the empirical sciences, on the one hand, and mathematics and logic, as well as metaphysical systems, on the other" (Popper 2005, p. 35). This problem had already been addressed by Hume, who attempted, for the first time, to measure it.

According to Popper, one can say that, to be part of science, a given hypothesis derived from a given conjecture must be falsifiable. In short, the method proposed by Popper demands that all proposed scientific hypotheses should be falsifiable by using empirical evidence.

Popper was strongly criticized with the advent of statistical theories, which apparently recommended a return to inductive logic. According to Popper, a probabilistic approach would apparently represent an insurmountable obstacle for a scientific theory based on deduction. According to Popper, "in fact, although probabilistic formulations may play a vital role in the field of empirical science, they reveal themselves in principle impossible to be strictly falsified" (Popper 2005, p. 471). However, Popper proposes that this argument is not sufficient to abandon the hypothesis of the causal nexus because the problem being approached is not deterministic but is instead stochastic because "the test of a statistical hypothesis is an operation of a deductive character—as are all other hypotheses" (Popper 2005, p. 471). Thus, "one first elaborates a test formulation so that it follows (or nearly follows) from the hypothesis" and has it later "confronted against experience" (Popper 2005, p. 471).

From these assumptions, Popper builds a logical method to test probabilistic hypotheses. Thus, "a probabilistic hypothesis can only explain statistically interpreted data and, as a consequence, can only be submitted to testing and corroboration by resorting to statistical summaries—and not by resorting, for example, to the 'whole existing evidence'" (Popper 2005, p. 472).

Thus, Popper seems to show that statistical methods (and, consequently, stochastic logic) are "in essence, hypothetical-deductive and operate by eliminating inadequate hypotheses, as all other methods of science operate" (Popper 2005, p. 472).

Another relevant point for discussion concerns the forms of capturing the so-called empirical evidence. In the context of the history of scientific development, it is important to perceive the role of the advancement of technology in the sense that it allowed some hypotheses to be empirically tested.

It just so happens that the scientific hypothesis that appeared with the emergence of Galileo's science could not be tested by direct sensory means (touch, smell, taste, vision, and hearing). For example, the technology of the telescope was fundamental to test the scientific hypothesis that the Earth revolved around the Sun. Thus, technological advances allowed phenomena to be observed not with the 'naked eye' but instead with an 'instrumented eye' or a 'technological eye'. Therefore, empirical tests must be considered from the possibility of using technologies for empirical testing that are compatible with the constructed hypotheses/models.

2.7.2 The Research Programs

Imre Lakatos developed his studies, like Kuhn, from a critical perspective of falsificationism and induction, proposing a structure entitled the Methodology of Scientific Research Programs, the purpose of which is to propose guiding solutions for the conduct of scientific research. To Lakatos (1970, p. 162), "Science itself as a whole can be considered as an immense research program with Popper's supreme heuristic rule: 'to construct conjectures that have greater empirical content than their predecessors'".

Moreover, scientific progress is made possible if the theories supporting it are well founded (Lakatos 1970). Therefore, the Methodology of Scientific Research Programs consists of methodological rules that seek to identify paths to follow in conducting research (positive heuristic) or paths to be avoided in conducting research (negative heuristic) (Lakatos 1977).

The negative heuristic is formed by a hard core that contains basic assumptions regarding the program; this core is protected from falsification due to a protective belt (Chalmers 1999). Lakatos (1970) claims that this protective belt is composed of a series of auxiliary hypotheses that aim to protect the program's irreducible core.

The positive heuristic, in turn, is composed of a collection of suggestions for "how to change and develop the 'refutable variants' of the research program, and how to modify and enhance the 'refutable' protective belt" (Lakatos 1970, p. 165). The goal of this heuristic is to prevent some irregularities found in the program from confounding the researcher (Lakatos 1970). The positive heuristic also presents a series of models that simulate reality (Lakatos 1970).

According to Lakatos (1977) in his methodology, scientific conquests belong to respectable investigation programs that can be evaluated according to their contributions to a given problem. When one research program overtakes another, a scientific revolution takes place (Lakatos 1977). The research program progresses by modifying the protective belt, and, in this way, opportunities for new discoveries appear to encourage the program's progress.

2.7.3 Research Paradigms

In his book The Structure of Scientific Revolutions, Thomas Kuhn (1967) presents the idea that neither the inductivist nor the falsificationist approach provide for a historical confrontation of their theories (Chalmers 1999). Therefore, the theory proposed by Kuhn (1967) emphasizes the advancement of science in the sense that when a scientific revolution occurs, some theoretical concept is abandoned and is replaced by another concept that seems to be more adequate in that historical moment. Chalmers (1999) depicts the perspective of scientific advancement proposed by Kuhn in Fig. 2.17.

Pre-science is what takes place when scientific activity occurs in a disorganized manner; i.e., it is not yet taking place within a specific paradigm. In this pre-science phase, there is no agreement among scientists on what or how to do research (Chalmers 1999).

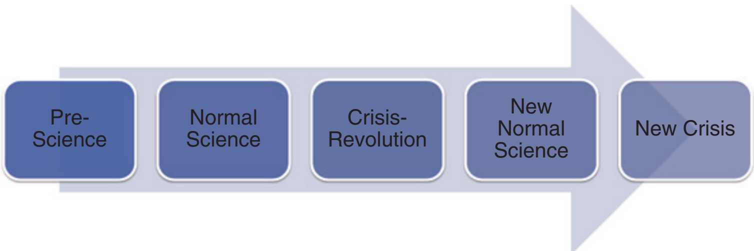


Fig. 2.17 Advancement of science according to Thomas Kuhn. *Source* Elaborated by the authors based on Chalmers (1999, p. 135)

After pre-science, there is a stage of normal science, which Kuhn (1967) defines as the stage in which a paradigm exists, and it is responsible for determining what is science and what is not, i.e., what is or is not relevant for research. When normal science begins to fail due to insufficient or inadequate explanations for some phenomena, the period termed a "crisis" begins. The crisis period lasts until a new paradigm is defined and, with it, a new normal science (Chalmers 1999).

It is worth clarifying the paradigms as defined by Kuhn (1967, p. 13): "universally recognized scientific achievements which, for some length of time, provide model problems and solutions to a community of science practitioners". These paradigms' rules are responsible for governing science when science is understood as the activity responsible for solving both theoretical and experimental problems (Kuhn 1967).

It is important to stress that to Kuhn (1967), to be considered valid in the scientific milieu, a new theory should be backed by its applications, and the solutions to problems should be tested in reality or in laboratory trials.

2.7.4 Epistemological Anarchism

In his work, "Against Method", Feyerabend (1975) claims that no scientific method is adequate because even if researchers try to follow rules in conducting their research work, they end up breaking some of the rules to ensure that there is scientific advancement from their investigations. He further claims that his goal "(…) is not to replace a set of rules with another set of the same kind: my goal is, rather, to convince the reader that all methodologies, including the most obvious ones, have limitations" (Feyerabend 1975, p. 43).

To Feyerabend (1975), the only valid rule in carrying out research work is that "anything goes." He claims that all scientific methods that have been proposed have failed at providing rules to guide scientific activity. Furthermore, Feyerabend stands out from other scholars of science because he does not subscribe to the superiority of science over other forms of knowledge (Chalmers 1999).

According to Feyerabend (1975), "The idea that science can and should be governed according to fixed and universal rules is at one time non-realistic and damaging. It is non-realistic because it assumes a far too simple view of man's talents and of the circumstances that encourage or cause its development. It is damaging because the attempt to enforce rules will necessarily increase our professional qualifications at the cost of our humanity. Moreover, the idea is harmful to science because it neglects the complex physical and historical conditions that influence scientific change. They make science less adaptive and more dogmatic" (Feyerabend 1975, p. 120).

In his main argument, the author criticizes the notion of the existence of a 'unique' universal scientific method and the existence of a central logic that answers, from the epistemological perspective, the construction of scientific theories. To corroborate his statement, Feyerabend cites Einstein when he says, "the external conditions that experience facts put [before the scientist] do not allow him, in erecting his conceptual world, to hold too tightly onto a given epistemological system. As a consequence, the scientist will appear, to the eyes of an epistemologist that holds on to a system, as an opportunistic and unscrupulous person…" (Feyerabend 1975, p. 20). Thus, the author proposes that "a complex medium, in which there are surprising and unforeseen elements, calls for complex procedures and challenges an analysis based on rules that were set beforehand…" (Feyerabend 1975, p. 20). It may be concluded from Feyerabend's explanations that the complexity of the phenomena that exist in reality requires flexible and plural method(s). For a complex reality, it is necessary that one does not depend exclusively on 'one single and better way' to investigate a problem at hand. In the words of Feyerabend, "the scientist must adopt a pluralist methodology. He must compare ideas first to other ideas instead of to 'experience', and he should try first to perfect rather than remove those concepts that are defeated in the confrontation" (Feyerabend 1975, p. 40).

Thus, Feyerabend (1975) proposes, as the only viable rule for science, the Anything-Goes logic. However, the notion of Anything-Goes should not be understood as an attempt to replace the themes identified by the Popperean School ('the falsificationism school'), by inductivism, or by the research programs proposed by Lakatos (Feyerabend 1975). The concept of Anything-Goes should be understood as a means to pluralize and make flexible the use of a method that implies the possibility of joint usage of the many currents that elaborate on the 'scientific method', as well as using other methods that are not cataloged as scientific but that may aid in the objective and concrete investigation of problems.

2.7.5 The New Production of Knowledge

Some criticism regarding the traditional scientific approach, and as a consequence the existing methods cited so far, can be addressed. Romme (2003) states that there is some difficulty in adapting the models used by the natural sciences to studies aimed at organizations.

Romme's (2003) criticism regarding the application of the social sciences to studies of organizations mainly concerns the large amount of discussion about epistemological issues and that little attention is paid to the researchers' objectives. The researchers' objectives are to understand the problems of the organization and, most importantly, to propose solutions to these problems (Romme 2003).

Seeking to overcome this difficulty in conducting studies in the field of management with the natural or social sciences approach, Gibbons et al. (1994) suggest that studies in this field make use of broader and more abstract knowledge. Such knowledge is aimed at building knowledge that is applicable to an organization. This type of knowledge is labeled as Mode 2. According to Romme (2003), research work conduct within an organization is best carried out when one has a less individual and a more pluralistic perspective in terms of methods. However, it is a common conclusion that knowledge production takes place through the application of the classical logic of the scientific disciplines, such as physics, chemistry, or biology. According to Gibbons et al. (1994), these disciplines represent the paradigm for the production of scientific knowledge.

Note that although these two types of knowledge production have their own particularities, there are interactions between them. In addition, the production of Mode 2 knowledge does not replace Mode 1: it completes it. However, the research work carried out currently uses markedly more Mode 1 knowledge than Mode 2 (Gibbons et al. 1994; Starkey and Madan 2001; van Aken 2004, 2005).

Mode 1 knowledge refers to a form of knowledge production with a disciplinary perspective; i.e., it represents the traditional production of knowledge (Burgoyne and James 2006; Gibbons et al. 1994). Problems studied with the Mode 1 approach to knowledge are solved in a context in which academic knowledge prevails, and there is no great concern regarding the practical applicability of the knowledge generated (Gibbons et al. 1994; Starkey and Madan 2001; van Aken 2004, 2005).

In fact, the production of Mode 1 knowledge, because it is disciplinary, usually distinguishes between fundamental knowledge and applied knowledge. Specifically, fundamental knowledge is founded on existing theoretical bases, whereas applied knowledge is founded on engineering and is concerned with the real use of knowledge (Gibbons et al. 1994; Starkey and Madan 2001; van Aken 2004, 2005).

Because of the characteristics of Mode 1, research work conducted under its precepts usually has no immediate potential for application (Burgoyne and James 2006), which is one of the limitations that leads some authors to consider developing their research work using the precepts for producing Mode 2 knowledge (van Aken 2005; Burgoyne and James 2006; Gibbons et al. 1994).

As a consequence, Mode 2 knowledge can be explained as a system for producing knowledge that focuses on its application; i.e., it covers all of the production of knowledge for the advancement of science up to knowledge that can be applied for the solution to the real problems of professionals inside organizations (Burgoyne and James 2006).

Gibbons et al. (1994) claim that Mode 2 knowledge rejects a linear view of knowledge transference. The knowledge that is produced must have a constructivist approach, and transdisciplinarity is the key point for its advancement. Transdisciplinarity, in this context, can be perceived as the knowledge that arises from the application's context itself. Thus, transdisciplinarity may have its own theoretical structure and specific research methods that cannot always be visualized in the traditional production of knowledge (Mode 1) (Gibbons et al. 1994; Starkey and Madan 2001; van Aken 2004, 2005). The concepts related to the production of Mode 2 knowledge will be explored in greater depth in the next chapter.

Once the main characteristics of the traditional sciences have been presented along with their trajectory over time, concepts related to the main theme of this book, Design Science, must be introduced. Therefore, the next chapter presents some of the criticism of the traditional sciences, the history of Design Science, and the main concepts related to it.

References

Amaratunga, D., et al. (2002). Quantitative and qualitative research in the built environment: Application of "mixed" research approach. *Work Study, 51*(1), 17–31.

Ander-Egg, E. (1976). *Introducion a las técnicas de investigación social [Introduction to the techniques of social investigation]* (5th ed.). Buenos Aires: Editorial Hvmanitas.

Andrade, L. A., et al. (2006). *Pensamento Sistêmico: Caderno de Campo [Systemic Thought: Field Notes]*. Porto Alegre: Bookman.

Bardin, L. (1993). *L'analyse de contenu [Content Analysis]*. Paris: Presses Universitaires de France Le Psychologue.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. *MIS Quarterly*, n. September, 369–387.

Booth, W. C., Colomb, G. C., & Williams, J. M. (2008). *The craft of research* (3rd ed.). Chicago: The University of Chicago Press.

Bunge, M. (1980). *Epistemologia [Epistemology]*. São Paulo: TA Queiroz Editora Ltda.

Burgoyne, J., & James, K. T. (2006). Towards best or better practice in corporate leadership development: Operational issues in mode 2 and design science research. *British Journal of Management, 17*(4), 303–316.

Camerer, C. (1985). Redirecting research in business policy and strategy introduction: The state of the art. *Strategic Management Journal*, 6(March 1983), 1–15.

Capelle, M. C. A., Melo, M. C. O. L., & Gonçalves, C. A. (2003). Análise de conteúdo e análise de discurso nas ciências sociais [Content analysis and discourse analysis in social sciences]. *Revista Eletrônica de Adiministração da UFLA*, 5(1).

Caregnato, R. C. A., & Mutti, R. (2006). Pesquisa qualitativa: análise de discurso [Qualitative research: discourse analysis]. *Texto Contexto Enferm, 15*(4), 679–684.

Cauchick Miguel, P. A. (2007, April). Estudo de caso na engenharia de produção: estruturação e recomendações para sua condução [Case study in production engineering: Structure and recommendations for conducting one]. *Produção*, *17*(1), 216–229.

Cauchick Miguel, P. A.; Ho, L. L. Levantamento Tipo Survey. [Survey] In Campus, E. (Ed.). *Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações* (2. ed., pp. 75–102). Rio de Janeiro: [s.n.].

Chalmers, A. F. (1999). *What is this thing called science?* (3rd ed.). Sidney: Open University Press.

Coughlan, P., & Coughlan, D. (2002). Action research for operations management. *International Journal of Operations & Production Management, 22*(2), 220–240.

Denyer, D., Tranfield, D., & van Aken, J. E. (2008, 1 March). Developing design propositions through research synthesis. *Organization Studies*, *29*(3), 393–413.

Dicicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education, 40*(4), 314–321.

Dubé, L., & Paré, G. (2003). Rigor in information systems positivist case research: current practices, tre. *MIS Quarterly, 27*(4), 597–635.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532–550.

Ellram, L. M. (1996). The use of the case study method misconceptions related to the use. *Journal of Business Logistics, 17*(2), 93–138.

Feyerabend, P. (1975). *Against method*. New York: New Left Books.

Forza, C. (2002). Survey research in operations management: A process-based perspective. *International Journal of Operations & Production Management, 22*(2), 152–194.

Gibbons, M., et al. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. UK: Sage Publications Ltd.

Gough, D., Oliver, S., & Thomas, J. (2012). *An introduction to systematic reviews*. London: Sage Publications Ltd.

Hair Jr J. F. et al. (2009). *Multivariate data analysis* (7. ed.). New Jersey: Prentice Hall.

Hegenberg, L. (1969). *Explicações Científicas: Introdução à filosofia da ciência [Scientific Explanations: Introduction to the philosophy of science]*. São Paulo: Editora Herder.

Hume, D. (1999). *An enquiry concerning human understanding*. Oxford: Oxford University Press.

Kuhn, T. S. (1967). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lacerda, D. P., Caulliraux, H. M., & Spiegel, T. (2014). Revealing factors affecting strategy implementation in HEIs – a case study in a Brazilian university. *International Journal of Management in Education, 8*(1), 54–77.

Lakatos, I. (1970). *Criticism and the growth of knowledge*. Cambridge: Cambridge University Press.

Lakatos, I. (1977). *The methodology of scientific research programmes: Philosophical papers* (Vol. 1). Cambridge: Cambridge University Press.

Mangan, J., Lalwani, C., & Gardner, B. (2004). Combining quantitative and qualitative methodologies in logistics research. *International Journal of Physical Distribution & Logistics Management, 34*(7), 565–578.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems, 15*, 251–266.

Mentzer, J. T., & Flint, D. J. (1997). Validity in logistics research. *Journal of Business Logistics*, *18*(I), 199–217.

Minayo, M. C. S. (1996). *O Desafio do Conhecimento [The Challenge of Knowledge]* (4. ed.). São Paulo-Rio de Janeiro: Hucitec-Abrasco.

Morabito Neto, R., & Pureza, V. (2012). *Modelagem e Simulação [Modeling and Simulation]. In: Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações* (2. ed., pp. 169–198). Rio de Janeiro: Ed. Campus, 2012.

Morandi, M. I. W. M. et al. (2013). Foreseeing iron ore prices using system thinking and scenario planning. *Systemic Practice and Action Research*, n. Janeiro, 1–20.

Pandza, K., & Thorpe, R. (2010). Management as design, but what kind of design? An appraisal of the design science analogy for management. *British Journal of Management, 21*(1), 171–186.

Pidd, M. (1998). *Modelagem Empresarial: Ferramentas para tomada de decisão [Business Modeling: tools for decision-making]*. Porto Alegre: Artes Médicas.

Plummer-D'amato, P. (2008). Focus group methodology Part 1: Considerations for design. *International Journal of Therapy and Rehabilitation, 15*(2), 69–73.

Popper, K. (1963). *Conjectures and refutation*. New York: Basic Books.

Popper, K. (1979). *Objective knowledge: An evolutionary approach*. Gloucestershire: Clarendon Press.

Popper, K. (2005). *The logic of scientific discovery*. UK: Taylor & Francis e-Library.

Rodrigues, L. H. (2006). As Abordagens Hard e Soft [Hard and Soft Approaches]. In: *Pensamento Sistêmico—Caderno de Campo* (pp. 81–85). Porto Alegre: Bookman.

Romme, A. G. L. (2003). Making a difference: Organization as design. *Organization Science, 14*(5), 558–573.

Saunders, M., Lewis, P., & Thornhill, A. (2012). *Research methods for business students* (6th ed.). London: Pearson Education Limited.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Currency Doubleday.

Shareef, R. (2007). Want better business theories? Maybe Karl Popper has the answer. *Academy of Management Learning & Education, 6*(2), 272–280.

Simon, H. A. (1996). *The sciences of the artificial* (3rd ed.). Cambridge: MIT Press.

Starkey, K., Madan, P. (2001). Bridging the relevance gap: Aligning stakeholders in the future of management research. *British Journal of Management*, *12*(Special Issue), S3–S26.

Sun, L., & Mushi, C. J. (2010). Case-based analysis in user requirements modeling for knowledge construction. *Information and Software Technology, 52*(7), 770–777.

Thiollent, M. (1985). Uses of knowledge: Some methodological alternatives. In: *Speciale Uitgave van Systemica Tijdsschrift van de Systeemgroep Nederland* (pp. 115–124). Holanda: Delft University Press.

Thiollent, M. (2009). *Metodologia da Pesquisa-Ação [Methodology of Action research]* (17th ed.). São Paulo: Cortez.
van Aken, J. E. (2004). Management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules. *Journal of Management Studies, 41*(2), 219–246.
van Aken, J. E. (2005). Management research as a design science: Articulating the research products of mode 2 knowledge production in management. *British Journal of Management, 16*(1), 19–36.
Werneck, V. R. (2006). Sobre o processo de construção do conhecimento: o papel do ensino e da pesquisa [On the process of knowledge construction: the role of teaching and research]. *Ensaio: Avaliação e Políticas Públicas em Educação*, *14*(51), 173–196
Yin, R. K. (2013). *Case study research: Design and methods* (5th ed.). Newbury Park, CA: Sage Publications Inc.

Suggested Reading

Booth, W. C., Colomb, G. C., & Williams, J. M. (2008). The craft of research. 3. ed. Chicago: The University of Chicago Press.
Chalmers, A. F. (1999). What Is this thing called science? (3rd. ed.) Sidney: Open University Press.
Checkland, P. (1981). *Systems thinking, systems practice*. Michigan: Wiley.
Hegenberg, L. (1969). *Explicações Científicas: introdução à filosofia da ciência [Scientific Explanations: Introduction to the philosophy of science]*. São Paulo: Editora Herder
Simon, H. A. (1996). *The sciences of the artificial* (3rd. ed.). Cambridge: MIT Press.

http://www.springer.com/978-3-319-07373-6

Design Science Research
A Method for Science and Technology Advancement
Dresch, A.; Lacerda, D.P.; Antunes Jr, J.A.V.
2015, XVIII, 161 p. 71 illus., 69 illus. in color., Hardcover
ISBN: 978-3-319-07373-6