Chapter 2
Information Systems Research as a Science

2.1 About Science

A friend once gave me a book called *What Is This Thing Called Science?* (Chalmers, 1999) to help me understand the nature of science. My immediate response was that I did not need it as I was already a tenured associate professor with a good track record in publishing and the promise of many publications to come. Clearly, I thought, I know what science is about.

I could not have been more wrong. This is not to say that all my prior efforts were fallible, misguided, and successful only by chance, but learning about the basic principles of science opened my eyes to some fundamental elements that govern much scholarly work.

Scholarly research that is worthy of a doctoral degree could be described as "scientific research" that conforms to systematic procedures, a method of "scientific inquiry." Science is the attempt to derive knowledge from facts using certain methods in a systematic and organised way.

Historically, two categories of science have evolved: natural sciences and social sciences. The **natural sciences**, which concern the study of naturally occurring phenomena and objects, include fields like chemical sciences, physical sciences, life sciences, and biological sciences. The phenomena under scrutiny are real and tangible objects like bodies, plants, and matter, although some objects, such as subatomic particles, chemical elements, and microscopic organisms, are difficult to observe.

The **social sciences** concern the study of people and collections of people. These sciences comprise fields like psychology, sociology, organisational science, and economics. All studies involving humans are part of the social sciences.

The distinction between natural science and social science is important because the modes of inquiry and research processes for the two can differ. The natural sciences are often referred to as "exact" sciences as inquiries in the natural sciences rely on precise measurements of phenomena and their properties. (This account of

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the relationship between the exact sciences (mathematics) and their applications in natural sciences, like physics, is very simplistic. There are many nuances to this relationship that are not covered in this text.) Examples of such work are in any high school chemistry or physics book. In the natural science of physics, for example, properties like the speed of light and gravity have been calculated precisely, although Heisenberg's uncertainty principles state a fundamental limit on the accuracy with which certain pairs of physical properties of a particle, such as position and momentum, can be simultaneously known. Still, for the purpose of our argument here, the natural sciences are largely exact.

To illustrate this point, consider the first direct observation of gravitational waves on 14 September 2015. Scientists had tried to directly prove the existence of such waves for more than 50 years. The ripple in space-time that was finally noticed had the length of a thousandth of the width of a proton, proportionally equivalent to changing the distance to the nearest star outside the solar system by the width of a human hair. What is astonishing is that Albert Einstein predicted the existence of gravitational waves in 1916 and also predicted that events in the cosmos would cause distortions in space-time that spread outward, although they would be so minuscule that they would be nearly impossible to detect. In 2015, detection was finally possible, and the phenomenon occurred precisely as Einstein predicted.

This level of precision in prediction or proof is pretty much impossible in the social sciences, where phenomena and the measurements we use to collect data about them are more vague, imprecise, non-deterministic, and ambiguous. To illustrate this point, think about a study that examines whether happy people sleep more or less than unhappy people. You will inevitably run into problems as soon as you try to figure out how to define—let alone measure precisely—what happiness is or when you try to isolate the cause of variations in sleep length. There could be noise in the bedroom, light shining through the window, more or less wind wafting through the room, differences in what the person ate or did that day, all of which could affect sleep patterns Among these conditions, any one of them or a combination of any of them may be related to sleep and some definition of happiness!

One of the many manifestations of the issue of exactness in science in the happy-people-sleep-differently example is the challenge of *measurement error*. Measurement error is invariably present in the social sciences because the phenomena that are studied are complex, vague, ambiguous, and dynamic: happiness can mean different things to different people or at different times, and it can manifest in different ways. If the thing itself is so hard to grasp, how can an even carefully constructed measurement of it ever be precise? In the social sciences, the phenomena we study cannot be faithfully defined or isolated precisely, so there will always be imprecision in how we study our phenomena of interest and, therefore, in the findings we obtain.

We will return to this issue later in this book, but for now, be aware that, as a scholar in information systems, a discipline that is socio-technical and deals with social behaviour in the forms of individuals/organisations/economies/other collectives, you are a part of the social sciences. As soon as our investigation concerns a human element, imprecision, vagueness, and ambiguity creep into our research and you cannot definitively "prove" anything.

Another challenge of information systems as a social science is that our phenomena are dynamic, not stable. In the natural sciences, many of the phenomena are largely invariant over time. The laws of gravity do not change. The anatomical structures of beings, such as our skeletons, do not change except through evolution over eons; for most purposes, we can consider them to be invariant. In consequence, once we have figured out something about an invariant object, we "know" it and can move to the next question. Medical doctors take a long time during their education to study the anatomy of human bones, but once finished they know human anatomy.

The ability to "know" something is different in the social sciences, particularly in information systems, as our phenomena change and evolve all the time. When you study how one collective of people acts—say, during an emergency—the results will be different at a different point in time, such as when the same group experiences a second emergency. This is because people learn and adapt their behaviours and the context will be different—a different place, a different time, a different set of experiences.

In information systems, the situation is even more complicated. Not only the social elements are dynamic (people change) but also the technical elements. Digital information and communication technologies change and evolve all the time. Computers get faster, better, and cheaper, and new technology replaces the old. We could study the same thing over and over again because the setting, context, and phenomenon itself will always be different. It would be next to impossible to make an accurate prediction for a hundred years into the future like Einstein did about gravitational waves.

Personally, I like that the information systems field is inherently dynamic and ambiguous. It forces us to be as precise as possible to approximate the phenomena we want to study and measure. It also means that our problems and interests change all the time. We are in a constant chase with reality, trying to catch up with all the changes to the technical and social elements that come together when people develop or use digital technology. I like to think that in this field, we will have always have work to do and the work can never be boring.

2.2 Scientific Knowledge

Given the distinctions between natural sciences and social sciences, consider the aim of science that we mentioned in Chap. 1—that science "contributes to the advancement of human knowledge." The goal of scientific inquiry is to discover laws and propose theories that can explain the natural or social, tangential or latent phenomena that concern us. Scientific knowledge is produced as an outcome of scientific inquiry.

Given the issues of precision and dynamism, the challenge of this goal is that this scientific knowledge can be imperfect, vague, and sometimes even incorrect in the social sciences because of the measurement error that creeps into scientific studies.

The key insight here is that all scientific knowledge is by definition a set of *suggested explanations* of particular phenomena. I often illustrate this notion by reminding students that at one time, we *knew* that the earth was flat. Our theories, which were mostly inspired through western religion as well as the limited measurements of the time (look at the horizon and see how the ocean "ends" at a certain line), suggested this knowledge to be accurate. Now we presumably *know* that this theory of the earth was not correct. New evidence was obtained through sailing around the earth without dropping off the edge. Later, astronauts observed from a distance that the earth is spherical. These new data and new observations led scientists to conclude (well, suggest) that the earth is a sphere, not a flat disk. They have devised measurements, such as those taken from planes flying at elevations of more than 35,000 feet, where one can observe the curvature of the earth. The evidence, in terms of data and mathematical proof, is substantial, increasing our trust in the suggested explanation instead of "trusting our eyes" when we gaze at the horizon.

This example shows that scientific knowledge is tentative and bound to the particularities of a specific point in time. The body of scientific knowledge in a domain—that is, the outcome of all research to date—is always the *current accumulation* of suggested theories, evidence, and measurement methods in that domain.

This definition of the body of knowledge makes no statement about the quality of the body of knowledge as the theories, evidence, and measurement methods may be good or poor. We all learn about examples like Ptolemaic, geocentric, and heliocentric astronomy that show how new knowledge supersedes existing knowledge. Such new knowledge could be a new theory, such as when Newton's ideas about gravity replaced Aristotelian physics, but it could also be new evidence, like results and/or observations that may either support or refute a scientific idea. For example, John Latham discovered black swans in 1790, which forced an update to the prevalent theory that all swans are white.

Progress in scientific inquiry—that is, the advancement of general human knowledge—can be examined by comparing how well we improve the current accumulation of theories, evidence, and measurements in a certain domain. For instance, a contribution could be an improvement in the explanatory power of a theory about a certain phenomenon. We could also add to the body of knowledge by finding better evidence of a theory or making more accurate measurements.

How can one achieve such a contribution? The body of knowledge focuses essentially on two concepts—theory and evidence—and their relationship, as shown in Fig. 2.1.

Thus, we can contribute to the body of knowledge in three ways:

(1) **Improving our theories that contain explanations of phenomena**: for example, research on theories that explain why people accept or reject information technology over time has improved these theories by identifying additional, originally not considered factors like habit, emotion, and anxiety, which add to our initial understanding that we accept technology when it is useful and easy to use (Venkatesh et al., 2016). Chapter 3 returns to the question of how we arrive at better theories.

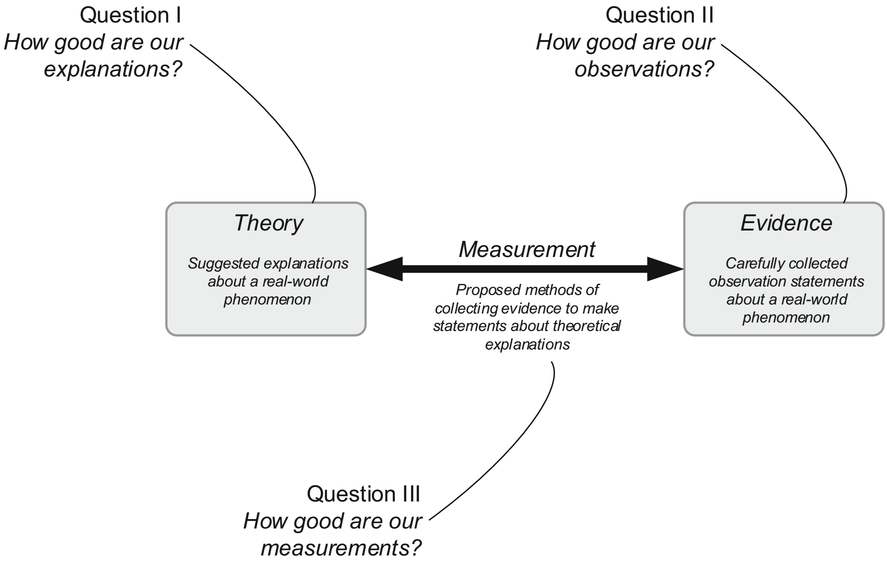

Fig. 2.1 The body of knowledge

(2) **Improving our scientific evidence**: for example, we may be able to collect data about a phenomenon for which no observations exist to date. A prime example is Darwin's voyage on *The Beagle*, when he encountered and systematically described many previously unknown species of plants and animals. This evidence allowed him, as well as other scholars, to refine theories about plants and animals and laid the groundwork for a whole new theory, the theory of evolution. Arriving at this new theory was possible only because systematic statements about observable facts were first created through careful exploration and observation. We return to methods of observation later in Chap. 5.

(3) **Improving our methods for collecting observations in relation to theory**: here is an example from the history of science. One of the most important contributions Galileo Galilei made was improvements he invented for telescopes. Starting with a telescope with about 3x magnification, Galileo designed improved versions with up to about 30x magnification. Through the Galilean telescope, observers could see magnified, upright images of the earth and sky. The new telescope yielded greatly improved measurements over those that were possible with the naked eye. It was only through these refined instruments that Galileo noted how the positions of some "stars" relative to Jupiter changed in a way counter to what was possible for stars that were "fixed," the current theory at the time. He discovered that the "fixed stars" were sometimes hidden behind Jupiter.

The improved measurements of Jupiter's satellites created a revolution in astronomy, as a planet with smaller bodies orbiting it did not conform to the principles of Aristotelian cosmology—the then prevalent astronomical theory, which held that all heavenly bodies should circle the earth.[1] Still, we know now that Galileo was right and that this breakthrough was possible because he initially did not refine the theory or observations but instead improved our ability to measure relevant phenomena.[2]

These examples illustrate the manifold ways in which scientific progress can be achieved, but they do not answer the question concerning how recognisable progress can be achieved. To answer that, we must look at the process of scientific inquiry and the postulates of the scientific method.

2.3 Scientific Inquiry

In Chap. 1, we ascertained that, in doctoral research, we execute studies that comply with two key principles of scientific research: the research work advances human knowledge, and it conforms to systematic principles that govern the collection, organisation, and analysis of data. Then Chap. 2 has illustrated three main ways to advance human knowledge: by creating scientific output in the form of contributions to theory, evidence, or measurement. Now we turn to the second principle, the process of scientific inquiry. Scientific inquiry refers to how scientists study the natural world and propose explanations based on the evidence derived from their work. It defines the process of academic work using accepted techniques and principles for investigating real-world phenomena.

A doctoral program deals with only one type of research, the class of scientific research. For research to be called scientific, scientific inquiry requires that the research process must be based on gathering empirical and measurable evidence that is subject to specific principles of reasoning. In other words, scientific research builds on principles that are accepted by scientists and that help to ensure that the outcomes meet the expectations for transparency, codification, reproducibility, and communicability. **Transparency** refers to the sources of the resulting scientific knowledge being traceable and verifiable. **Codification** means that the knowledge can be represented in some form—words, symbols, video—that enables interpretation by someone other than the originator. **Reproducibility** requires that the knowledge be possible to replicate or copy. Finally, **communicability** means that the

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[1] Galileo initially endured significant resistance to his findings because his measurement instrument, the telescope, was not trusted as a scientific instrument. It took decades of replication, a scientific principle I explain below, before his findings were confirmed to the extent that they were trusted as valid observational evidence.

[2] Refining measurements remains relevant to this day. For example, improvements in neuroscientific measurement methods like fMRI scanners have recently been developed and provide much more precise measurements of brain activities than any other measurement instrument previously used in cognitive psychology.

knowledge must be in such a form that it can be conveyed, discussed, and challenged by others.

Although research procedures vary from one field of inquiry to another, several common features in scientific research methods distinguish scientific inquiry from other methods of obtaining knowledge. Most important is that scientific inquiry must be *as objective as possible* to reduce biased interpretations of results, maintain a neutral and (where possible) factual position on a phenomenon, and minimise the dependency and partiality of the research team or any interpreter of the findings.

To ensure as much objectivity as possible, scientific research must follow the principles of replicability, independence, precision, and falsification (I know that last one sounds counter-intuitive, but read on):

(1) **Replicability**

Replicability refers to the extent to which research procedures are repeatable such that the procedures by which research outputs are created are conducted and documented in a manner that allows others outside the research team to independently repeat the procedures and obtain similar results. The question is, "If I repeated your research based on how you conducted it and described it to me, would I get the same results?" Replicability relies to an extent on carefully detailed documentation, archival, and sharing of findings, data, measurements, and methodologies so they are available for scrutiny by other scientists such that they can verify the results by reproducing them.

Replication in the social sciences has come to the forefront of public attention in part because of the replicability crisis (Yong, 2012) that emerged around 2010, when scientists noted that many scientific studies were difficult or impossible to reproduce. A survey of 1,500 scientists in 2016 found that 70 percent of respondents had not been able to reproduce at least one experiment of other scientists and 50 percent had not been able to reproduce one of their own experiments (Nature Videos, 2016). In my own work, I made both experiences as well.

(2) **Independence**

Independence concerns the extent to which the research conduct is impartial and free of subjective judgment or other bias stemming from the researcher or researcher team. Independence can be easier to achieve when one is working with factual, objective, precise data and can be harder in interpretive research, where the researcher attempts to explain a phenomenon by interpreting participants' sentiments or statements about it. As Chap. 5 will show, different research methods are challenged by and deal with independence in different ways; for example, in some studies, teams of external coders are used so as to avoid the researchers' subjective judgment.

Independence distinguishes scientific research from other forms of problem-solving, such as consultancy, where the researcher has contractually stipulated vested interests, such as wanting to be paid for his or her work and not wanting the organisation that is paying for the work disapprove of it by arriving at an expensive or disappointing outcome.

(3) **Precision**

The precision principle states that the concepts, constructs, and measurements of scientific research should be as carefully and precisely defined as possible to allow others to use, apply, and challenge the definitions, concepts, and results in their own work. Especially in the social sciences, many concepts—happiness, satisfaction, joy, anxiety, and so forth—are difficult to define, and they carry many connotations. Precise definitions and measurements are critical to ensuring that others can comprehend, use, and even challenge the researcher's interpretation of the concept.

(4) **Falsification**

Falsification is probably the most important principle in scientific research. It originates from the thinking of philosopher Popper (1959), who argued that it is logically impossible to prove theories in scientific research. Instead, he argued that scientific theories can only be disproven or falsified. In other words, falsifiability describes the logical possibility that an assertion, hypothesis, or theory can be contradicted by an observation or another outcome of a scientific study or experiment. That a theory is "falsifiable" does not mean it is false but that if it is false, then some observation or experiment will produce a reproducible and independently created result that is in conflict with it.

The falsification argument carries two important implications. First, it draws a clear boundary around the possibilities of scientific research: our theories are sets of suggested explanations that are assumed to be true because the evidence collected to date does not state otherwise. To illustrate, Newton sat under the apple tree and apples fell on his head, which allegedly gave him inspiration about a theory of gravity. Per that theory, apples fall to the ground because of gravitational forces exerted by the earth's core that pull them toward the ground. Does the theory conclusively and irreversibly predict that all apples will always fall to the ground? No, it does not. There is no logical way to prove conclusively that all apples will continue to fall to the ground even though all apples to date have done so. If we were to find an apple that, say, scoots off into the sky, we would have found evidence that is contrary to the theoretical prediction and would have falsified Newton's theory.

The second implication of the falsification argument is that a good scientific theory is one that can be falsified. This principle suggests that theories must be stated in a way that they can, hypothetically, be disproven. If we do not define a theory in a way that allows us or others to disprove the theory, then we have not complied with the scientific inquiry process and cannot offer a scientific contribution to the body of knowledge. For example, the assertion that all swans are white is falsifiable because it is logically possible that a swan can be found that is not white. By contrast, consider the example of the Rain Dance Ceremony theory:

> *If you perform the Rain Dance Ceremony and all the participants are pure of heart, it will rain the next day.*

> Proposing this theory is not a scientific undertaking because the theory is not falsifiable: if you perform the ceremony and it rains, the theory is confirmed. If you perform the ceremony and it does not rain, it contends that one of the participants was not pure of heart, so again the theory is confirmed. Unfortunately, being pure of heart is not a property that we can precisely, reliably, and independently measure, so we cannot create a scenario in which we could disprove the Rain Dance Ceremony theory.

The idea behind the principles of scientific inquiry is not to accredit or discredit research endeavours but to separate scientific research from other fields of research. A common example is that of theology, which is not a science because its research processes do not conform to the principles of scientific inquiry. For one thing, the principle of falsifiability is violated because phenomena like divine intervention cannot be tested or verified independently. Similarly, the humanities, literature, and law are not sciences in that their work relies heavily on the ability to interpret a complex material in a sense-making process, a procedure that is not independently repeatable because it is subject to the individual who performs the inquiry.[3]

The principles of scientific inquiry are themselves only a sort of theory of science in that they are not "true" in any sense; they are merely what many scientists agree to be a useful pattern for doing science, which relies on systematically testing theories, challenging evidence, and improving measurements, to see if what we think about the universe is correct. Not all scientists agree on these principles. For example, Feyerabend (2010) suggested in an analysis of substantial scientific breakthroughs that many of the great scientific discoveries were made by chance rather than by applying a rigid process of inquiry. He concluded that conforming to particular methods of "scientific inquiry" would actually limit the ability to create significant breakthroughs through science. Also, some social scientists question some notions, such as falsification or independence, as means to guarantee the quality of research. For example, Giddens (1993) argued that social science, unlike natural science, deals with phenomena that are subjects, not objects, so they are in a subject-subject relationship with a field of study, not a subject-object relationship. In this situation, he continued, social scientists inevitably deal with a pre-interpreted world in which the meanings developed by the study's subjects enter into the constitution or production of that world. In this understanding, there is not really space for objectivity and independence.

These discussions also have their place in the field of information systems, which is a *pluralistic* field, meaning that multiple positions of science are allowed to coexist. You can choose to follow the position of interpretive scholars (e.g., Walsham, 1995a), you can follow the position described through the principles of scientific inquiry, and you can even build your approach to science around Feyerabend (e.g., Hirschheim, 2019). While I like the pluralism of our field, it complicates things for those who conduct, evaluate, or apply science. Still, pluralism

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[3] These statements do not qualify these research inquiries as good or bad; they are merely used to distinguish different types of research.

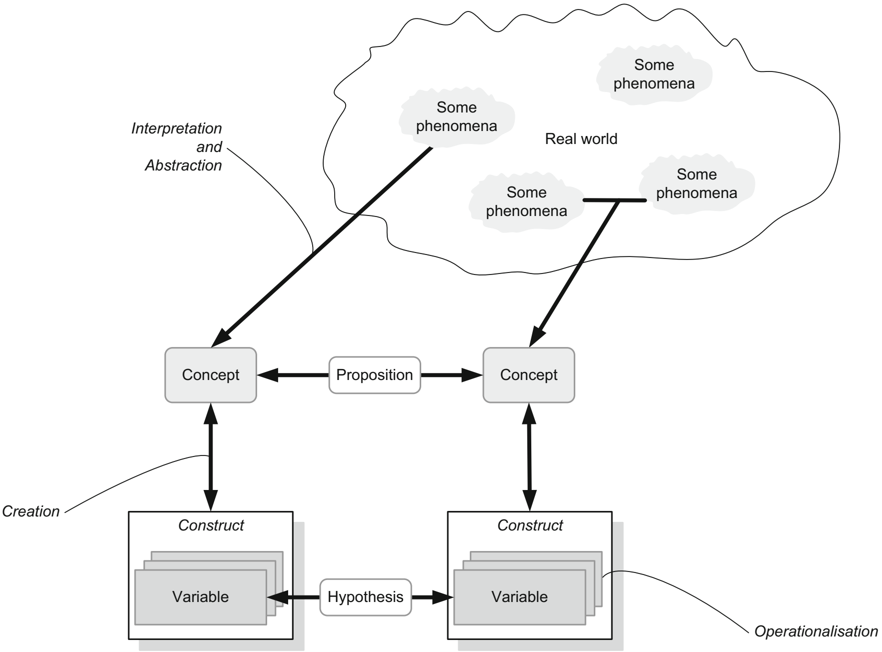

Fig. 2.2 Concepts in the scientific research process

promotes scientific progress since it allows advancements in human knowledge to be obtained from a proliferation of views rather than from the determined application of one preferred ideology. Every scientific framework can be judged on its productiveness or its efficacy in light of the goal of a research project. If a chosen approach is not effective or fruitful, it can be modified or something else can be tried.

2.4 Essential Scientific Concepts

One of the problems that I encounter frequently with doctoral students is that our conversations are hampered by our use of “standard” research concepts and terms when our definitions of terms like construct, concept, and variable may differ.

To address this problem, have a look at how I define some concepts in Fig. 2.2.

First, we need to define the term *concept*. A concept describes an abstract idea that is inferred or derived from instances that we perceive in the real world, that is, mental representations that we develop, typically based on experience. Concepts can be of real phenomena (dogs, clouds, gravity) as well as latent phenomena (truth, beauty, prejudice, usefulness, value).

We use concepts as a language mechanism to describe the general properties or characteristics that we ascribe to things or phenomena. For example, we use the concept of weight to describe the force of gravity on objects. Weight is a general property that applies to all tangible things in the real world. We can also use the same concept, weight, to illustrate the psychological state of someone who is experiencing stress, tension, and anxiety, as we do when we refer to the "weight on their shoulders." We also develop new concepts to describe a new or newly discovered property. Emotional intelligence, for example, is a concept that purports to describe our ability to identify, assess, and control our emotions and those of others. This concept has gained some prominence in a debate regarding whether it is a personality trait or form of intelligence not accounted for in current theories of personality and intelligence (which, by the way, are also concepts).

As abstract units of meaning, concepts play a key role in the development and testing of scientific theories. They give us a vocabulary with which to reason about real-world phenomena (or the link between two or more real-world phenomena, as shown in Fig. 2.2) and a way to describe the characteristics or properties of those phenomena and their relationships. Concepts can be linked to one another via propositions, which are suggested, tentative, or conjectured relationships between two or more concepts, such as that more intelligence leads to better decisions. Propositions are sometimes called conceptual hypotheses.

Note the keywords suggestion, tentativeness, and conjecture used above to explain the notion of a proposition. These terms characterise propositions as proposals for an explanation about how phenomena are related. Whether the propositions hold true is an entirely different question and typically an empirical one that we must answer using appropriate research methods.

The problem with concepts is that many of the *phenomena* we are interested in (satisfaction, empathy, intelligence, anxiety, skill, and so on) are imprecise because they are not directly observable. They are abstract and difficult to capture, define, and visualise because, in the social sciences, we are often concerned with understanding behaviours, processes, and experiences as they relate to "digital technology in use."

For example, take the simple proposition that "education increases income." The concepts of education and income are abstract, so they can have many meanings. As a result, such a proposition could be tested in potentially infinite ways, and many different results could be obtained, so a proposition cannot be tested. To testing them against data, they must be converted into operational hypotheses.

As Fig. 2.2 shows, hypotheses are suggested links between constructs. *Constructs* are operationalised concepts, where we take the abstract meaning of a concept, like education, and try to operationalise it to something in the real world that can be measured. Education, for instance, could be operationalised as the highest degree earned, which could be measured by ascertaining what degree (e.g., high school, undergraduate, graduate, postgraduate) a person had completed. The concept of income could be operationalised as annual salary in US dollars before tax (or monthly income after tax, or annual income after tax, and so on). In any case, a construct must be specified as precisely as possible.

Thus, a construct is an operationalisation of a concept in such a way that we can define it by measuring the construct against data. We use this process to describe fuzzy concepts in terms of constituent components that are defined in precise terms.

In doing so, we try to eliminate vagueness (how many centimetres exactly is a "tall" person?) and ambiguity (e.g., whether the statement "I own a bat" refers to an animal or a piece of sports equipment).

This process is mentally challenging. For instance, to operationalise the concept of prejudice, we would have to ask ourselves what prejudice means to us. Are there different kinds of prejudice (race, gender, age, religion, body type)? How can we measure them? Do we need to measure all of them?

Depending on the answers, we can create unidimensional or multidimensional constructs. *Unidimensional constructs* are composed of only one underlying dimension, such as weight, height, or speed, so they can be measured through one *variable*. A variable an the empirical indicator that allows us to approximate the underlying construct, a measurable representation or manifestation of a latent construct in the real world. For example, when we define the concept "weight" as the construct that describes the force gravity places on an object, we can define a measurement variable that specifies levels of weight using, for instance, a metric scale (in kilograms). Because weight is a relatively simple, unidimensional construct, there is typically no need to define multiple measurement variables as measuring a person's weight in kilograms and pounds would obtain the same result since the scales have a percental equivalency. Other good examples of unidimensional constructs are age, time, and income.

Gender has traditionally been used as a unidimensional construct with a simple measurement variable (male/female), but a wider range of genders is socially accepted now in many societies. Since most constructs are more complex, they are composed of a multidimensional set of underlying concepts. Intelligence, for example, cannot be measured by a single variable because the concept pertains to multiple kinds of abilities—abstract thought, communication, reasoning, learning, planning, problem-solving and emotional intelligence. Such constructs are called *multi-dimensional constructs* because they have multiple underlying dimensions, all of which are relevant to our understanding and use of the construct and all of which must be measured separately using dedicated variables. Taking the example of intelligence again, the IQ (intelligence quotient) score is the standardised outcome of a complex test that contains measurements of intelligence and abilities, like abstract thought, communication, creativity, learning, memory, problem-solving, reasoning, and visual processing.

Variables are measurable representations of constructs, and these representations create precise operationalisations of concepts that present mental abstractions of the properties of phenomena in the real world. By using variables, we can also speculate about links between empirical phenomena that feature in operationalised hypotheses. A *hypothesis* is the empirical formulation of a proposition of a testable relationship between two or more variables. Hypotheses are formulated so they are directly empirically testable as true or false and such that they allow for precise reasoning about the underlying proposition they represent. For example, the hypothesis that the "highest degree earned is related to annual gross salary" is a weak hypothesis because it fails to specify *directionality* (does the earning of a degree cause an increase or a decrease in annual gross salary?) or *causality* (does annual gross salary cause a specific degree or vice versa?). A strong hypothesis, by contrast, is "the higher the degree earned, the more annual gross salary is earned." As this example shows, hypotheses specify directionality as well as causality by delineating which variable leads to which effect on which other variable. Saying that "Europeans earn high annual gross salaries," for example, is not a hypothesis because it does not specify a directional/causal relationship between two variables, so we cannot collect meaningful data to evaluate the hypothesis, which violates the principle of falsification.

2.5 Further Reading

I found Chalmers' (1999) introductory book on the philosophy of science worthwhile for its elucidation of the common principles of good scientific inquiry. Popper's (1959) seminal book, *The Logic of Scientific Discovery*, provides a more detailed follow-up to my explanations of falsification. For a more critical view of the principles of scientific inquiry and their limitations, you can consult Feyerabend's (2010) *Against Method.* If you are interested in how interpretive scholars challenge typical principles of scientific inquiry, such as those I introduced, I can recommend several papers written by or co-authored by Myers (Klein & Myers, 1999; Myers, 1997) and the articles by Walsham (1995b, 2006).

A good introduction to essential concepts in information systems research is Bhattarcherjee's (2012) book on social science research. Similar term definitions can also be found in other introductory textbooks, such as those by Creswell (2009) and Reynolds (1971). Burton-Jones and Lee (2017) wrote a paper that does a good job defining the differences between constructs and measurements well.

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