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Knowing

What does it mean to know, and how do we discern truth in education research?

Royce Kimmons

Philosophy of Education

Epistemology

Epistemology, or the study of knowing, has been of philosophical interest for thousands of years. The concept of knowing is ingrained in our day-to-day lives, but there seem to be different types of knowing. This chapter will attempt to provide some groundwork regarding knowing that will be drawn upon in subsequent chapters.



If the goal of research is to come to know something about the universe, then we need to begin by having a clear understanding of what it means to know anything. On first exposure, this may seem like an absurd question. "Of course I know what it means to know ... I just know." Such a common-sense approach to knowledge seems reasonable until we encounter other people who don't *just know* the same way we do – which we constantly do – at which point we find ourselves needing to resort to providing evidence, making arguments, or sharing stories in order to either justify our own knowledge or to try to influence others to know what we know.

This problem of knowing is ancient because people have always valued the ability to know but have also always claimed to know things that they had difficulty proving, defending, or explaining. Some of the earliest evidences of this

problem date back to ancient Greek writings, such as Plato's recorded dialogue between Socrates and Meno, wherein Socrates, amongst other things, presents an apparent paradox of knowledge: "[A man] cannot search for what he knows – since he knows it, there is no need to search – nor for what he does not know, for he does not know what to look for." This is a problem for us, because if we cannot search for knowledge, then research is impossible, and if we only search for what we already know, then research is useless.

Epistemology, or the study of knowing (Steup, 2005), has been of philosophical interest for thousands of years precisely because the concept of knowing is ingrained in our day-to-day lives, but there seem to be different types of knowing and different types of certainty that are sometimes difficult for us to understand and articulate. The situation for education researchers is particularly poignant here because, in addition to grappling with our own knowing, we are also in the business of knowing about learning, which is itself a process of coming to know. So, we must grapple with knowing at multiple levels: for our students, for ourselves, and for our research audiences.

This chapter will attempt to provide some groundwork regarding knowing that will be drawn upon in subsequent chapters. I will begin by highlighting three types of knowing and then explore processes that we often follow to come to know something. I will then operationalize some terms that are commonly used in the realms of knowing, truth-seeking, and science so that we can have a common language for delving into important epistemological questions in subsequent chapters.

Key Terms

Abduction

A logical inference of a conclusion (or special case of inductive reasoning) that likely follows (but doesn't necessarily follow) from the provided premises and provides a reasonable explanation of the mechanism by which the conclusion follows.

Alternative Hypothesis

A proposed explanation of phenomena that deviates from received wisdom or current belief.

Deduction

A logical inference of a conclusion that necessarily follows from the provided premises.

Emic Perspective

An insider approach to research, or research from a native point of view.

Epistemology

The branch of knowledge that deals with knowing, such as what is known, how it is known, and how it is proven.

Etic Perspective

An outsider approach to research, or research from an observer point of view.

Fact

A true statement about a finite, specific, and observable thing.

Hypothesis

A proposed statement that is not known to be true or false but that can be tested for falsity.

Induction

A logical inference of a conclusion that likely follows (but doesn't necessarily follow) from the provided premises, generally from evidence of experience, frequency, or statistics.

Intersubjectivity

An assumption that knowing is a subjectively mediated process both between the subject (observer) and the world and also between different subjects (observers).

Law

A relational (often mathematical) predictive statement of relationship between phenomena that is finite, specific, and observable.

Null Hypothesis

A proposed explanation of phenomena that conforms to received wisdom or current belief.

Objectivity

An assumption that people can directly observe the world, or facts or truths in it, in an unbiased fashion and have an accurate knowledge of what they are observing.

Paradigm

A model or pattern we follow when conducting research, including both our surface-level methods as well as our deeper, often hidden, beliefs, attitudes, expectations, and values.

Subjectivity

An assumption that people can only understand the world as a mediated process of knowing that is directed by the biases, attitudes, expectations, and experiences of the subject or observer.

Theory

An explanation of the 'how' or 'why' of particular phenomena, typically referencing existing facts and laws.

Type I Error

A false positive error in which the null hypothesis is erroneously rejected.

Type II Error

A false negative error in which the null hypothesis is failed to be rejected even though it should have been.

Types of Knowing



The history of epistemology can broadly be summarized as a dialogue between two different types of knowing: objectivity and subjectivity. In this dialogue, thinkers have grappled with what we can actually know about things in the world (objects) when any knowing that occurs can only happen in the mind of the knower (subjects). In more recent years, sociologists, historians, and others have further complicated this issue by suggesting that focusing only on the lone observer/thinker in this process is limited because it ignores cultural or shared aspects of knowing. I will now explore each of these types of knowing – objectivity, subjectivity, and intersubjectivity – in more detail.

Objectivity



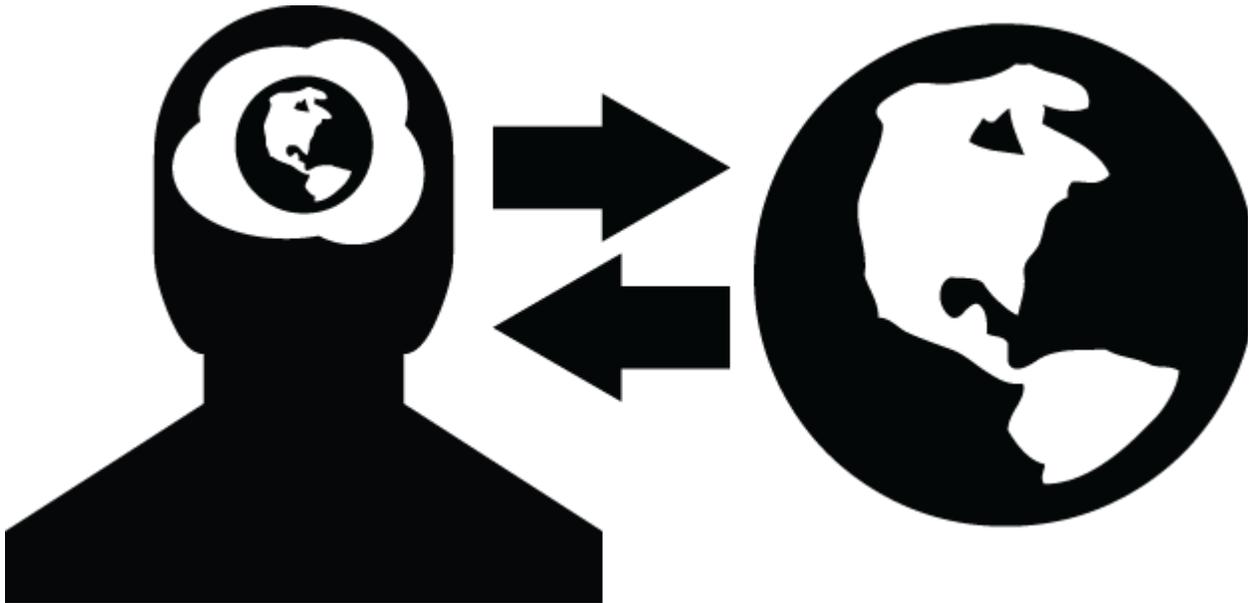
Objectivity assumes that people can directly observe the world, or facts or truths in it, and have an accurate knowledge of what they are observing (Reiss, 2014). In a simple case, a person (the subject) might observe a flower (the object) and be able to tell you what it is: “It is a pink rhododendron with five leaves.” If this is objectively true, then anyone else seeing the object would draw the same conclusion: “Yes, it is, in fact, a pink rhododendron with five leaves.” As long as we can make sure that the object doesn’t change and that anyone can observe the object under similar conditions with the same result, we can conclude that this is a truth embedded in the world: “This is a rhododendron, and it is pink.” In other words, objectivity assumes that the world can be accurately understood through unbiased observation.

Objectivity is the traditional goal of science and research because both assume that the world exists separate from the mind of the knower and that it can be universally known through observation and inquiry as a dispassionate (almost robotic) outsider. Like the lab-coat-clad scientist behind a one-way mirror, the objectivist researcher assumes that she can understand what she is observing from the outside-in and tries to separate herself completely from what she is observing. This is also called an etic perspective, wherein the researcher sees herself as a potential contaminant of what is being studied and intentionally separates herself physically, psychologically, and emotionally from it. For objectivist inquiry, the biases, emotions, intuitions, and rational limitations of the researcher are threats to the validity of

the observation, because they have the potential to warp the observation or (even worse) to make the researcher influence what is being observed.

Thus, when seeking objective knowledge, the only proper role of the knower is that of a machine-like observer who is carefully controlled and separated from what is being observed. By treating the knower in this manner, it is hoped that the actual observation will not be influenced and that any other knower, no matter who they are, will derive the same knowledge from the object being observed.

Subjectivity



Subjectivity, on the other hand, applies to knowledge as it exists in the mind of the subject or as an interpretation of objects in the universe. In the simplest case, a person (the subject) might still observe a flower (the object), but what they actually perceive, learn, or know as a result of this observation will always be determined (or at least influenced) by the knower. In matters of aesthetics, this is clearly understandable, because some might think that the flower is beautiful while others might not, but it can also apply to more seemingly concrete aspects of knowing as well. In this case, would you know a rhododendron from a pansy? Even making this distinction to categorize the flower would require certain prior knowledge on the part of the subject, which would dictate the categorization. Would you also see it as pink? Or would you see red? Or mauve? Or grey (in the case of deuteranopic people or animals such as dogs that have different photoreceptor cone structures)?

This latter point is important because when talking about objectivity, we assumed that the observer could objectively state that the flower was pink, but this assumes that color itself is something that is universal and exists in the world. However, color is itself only a physiological interpretation of wavelengths, which, as shown above, humans might interpret differently but, even more importantly, is nothing but an interpretation and is not a characteristic of the flower itself. The petals of the flower might be made of such a substance that they reflect certain wavelengths of light, but they do not objectively have a color any more than a politician can be said to have character or a painting can be said to be beautiful. Color is a perception and, as such, it can only ever exist in the mind. (This is similar to Berkeley's famous question that "if a tree falls in the forest and no one hears it, does it make a sound," because sound only exists as an interpretation in the mind of the knower.)

Thus, a weak claim for subjectivity would be that at least some knowledge is subjective in nature, meaning that it is interpreted and categorized entirely by the observer (subject), but many argue for a stronger claim that all knowledge can only ever be subjective. This calls into question the possibility of objectively knowing anything because no matter how carefully the observer is controlled, the very act of observation requires interpretation and may even be a form of influence (such as the Heisenberg uncertainty principle and "observer effects" in quantum mechanics). This can be

interpreted to make any claims of objectivity uncertain and suggests that knowing cannot exist outside of or separate from the knower. When applied to research, subjectivist approaches to knowing would recognize and embrace the researcher's role in the research process. Also called an emic perspective, this would typically require the researcher to experience the world firsthand as a participatory insider and to articulate (and value) how their own biases, attitudes, expectations, and experiences might be shaping what they are learning through this process of inquiry.

Intersubjectivity



One clear problem with **subjectivity** is that if all knowledge is subjective, then how can we ever prove anything to one another or claim to know anything about the universe with any level of certainty? In response, some will double-down on **objectivity** as the only reasonable path forward, while others might propose an **intersubjective** approach, which seeks to find consensus, commonality, or shared experiences between subjective individuals. Similar to subjectivity in how it views the individual's relationship to the world, intersubjectivity is nonetheless markedly different, because it assumes that people and the act of knowing is inherently social (not individualistic) in nature.

This means that intersubjective knowledge could only be gained as the process of meaning-making extends beyond the person-world (subject-object) relationship to encompass subjective experiences and knowledge between multiple, diverse people (subjects). An example of this would be a historian wanting to accurately understand the U.S. Civil War who studied the artifacts and experiences of various impacted peoples, including rich, poor, black, and white Northerners and Southerners. In so doing, the historian would not be seeking "the accurate" depiction of what happened (as with objectivity) or even one group or person's limited perspective of what happened (as with subjectivity) but would be seeking to more deeply and fully understand the event by weighing the biases, attitudes, beliefs, and experiences of all involved to better perceive the event as a shared experience.

Like subjectivity, intersubjectivity is not capable of making claims on absolute truth or the world as it objectively exists, but by focusing on shared, multifaceted knowledge, it is sometimes used as a seemingly more responsible, trustworthy, or rich way of knowing than subjectivity. One research struggle with this approach, though, is that as multiple subjective experiences are meshed together, difficulties may arise for the researcher in determining whose perspectives to emphasize or highlight and whose perspectives to ignore or minimize. This typically requires some external standard of comparison (e.g., only including narratives that align with an existing assumption of objective truth) which can suggest overreach into objectivist aspirations, thereby subverting responsible subjectivist limitations.

Forms of Reasoning



The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge. (Stephen Hawking)

Not only are there different types of knowing, but we also follow different processes of reasoning to develop knowledge. There are at least three common processes that we follow, including deduction, induction, and abduction. You have probably heard of deduction vs. induction, but abduction is not commonly used outside of formal logic to describe a form of reasoning. Furthermore, most definitions of deduction vs. induction are only loose applications of what the terms actually mean in formal logic. We engage in each of these processes every day, and each connects to the three types of knowing in specific ways. Furthermore, all are used by researchers in some fashion, so we will now explore each in more detail.

Deduction

You might have heard that deduction means moving from generalities to particulars, while induction is the opposite, but this is not always accurate. Rather, the core of the difference between deduction and induction is certainty ([Doven, 2017](#)). **Deduction** is always completely certain, while induction is an educated, reasonable guess.

To illustrate, suppose that we know that “all planets that are members of our solar system move around the sun” and that “Mars is a planet.” If these two premises are true, then we can determine with complete certainty that “Mars moves around the sun,” because moving around the sun is implicit in a planet’s being in the solar system. In other words, the definitional premise we are using for “solar system” and “planet” means that something cannot be a planetary member of our solar system and not move around the sun. Therefore, if Mars is a planet, then it must always, completely, certainly move around the sun. In this case, we did move from a general law (the definition of planets in the solar system) to a specific case, but that is only incidental to the central characteristic of deduction, which is that the logical step we took was completely certain. We could test this, of course, but if we found that Mars did not, in fact, move around the sun, then there was a problem with our first premise, and it is therefore not true. In such a case, the logical movement itself wasn’t wrong, we were just coming from a false beginning.

Induction

Induction, on the other hand, uses gathered evidence or existing understandings, which generally come in the form of observations, data, or laws, to draw a conclusion that seems likely ([Hawthorne, 2004](#)). For instance, suppose that we know that “all life on Earth requires water.” From this, we might conclude that in order to have life, other planets must have water also, and we embark on discovering whether or not other planets have water as a precursor to life. We might even go so far as to conclude that “water is essential for life.” At least in this current argument, we have not provided any evidence as to why or how water is essential to life, but we are operating on the very strong evidence that the millions of species of life on Earth all require water to survive, which is a massive, very compelling dataset. Based on this, it seems reasonable to conclude that we would not find any life where there is an absence of water and would, therefore, train our search for life only on planets that have the possibility of water.

However, what if we did find life on another planet, and it did not have water? Would this invalidate our premise the same way it did in deduction? Of course not. The premise would still be true — all life on Earth would still require water — it is just our conclusion that was false. The difference here is that the inductive argument was making a calculated leap that seemed reasonable based on existing evidence (millions of species supporting the conclusion without a single contradicting case), but based on how the argument was structured, there could always be the opportunity for a counter-instance to arise where the conclusion did not necessarily follow from the premises.

Another characteristic of induction is that it operates off of likelihood rather than from an underlying rationale. We might, for instance, find that women are more likely to suffer from a specific disease than men at a ratio of 50-to-1 and inductively use this evidence to suggest that women should be screened for the particular disease even if we don’t understand why it might be more prevalent in women. If we then screened a particular woman and found that she did

not have the disease, this new evidence alone wouldn't invalidate our premise nor our conclusion that women should be screened for the disease. All that it would show was that our argument was inductive and, therefore, might not be accurate in every instance.

Abduction

By clarifying this difference between deduction and induction, we can now understand why abduction is also necessary. **Abduction** is a special case of induction where we not only draw a conclusion that seems likely based on the evidence but also attempt to explain or justify the conclusion by reference to some explanatory mechanism ([Douven, 2017](#)). For instance, suppose that we know that "the Earth is teeming with life and is in a Goldilocks zone (not too hot, not too cold)." When asked "Is there life on Neptune?" we might reasonably conclude "no" and proceed to explain that "based on what we know about life, no organisms could evolve or survive outside of a Goldilocks zone." In this case, it seems reasonable to inductively conclude that there is no life on Neptune from the simple fact that it is too dissimilar to the Earth in its location, but this argument goes one step further by imputing a causal mechanism to explain why the Goldilocks zone is essential to life.

This step may involve a certain level of creativity or imagination to provide the explanation and is likely why Albert Einstein famously quipped that "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution." Whenever scientists move beyond what is known to try to construct theories that explain the "why" or "how" of what is happening, they are involved in abduction, and this requires an imaginative leap to make connections that have not previously been made.

Could it still be possible that life exists on Neptune? Perhaps, but the argument for why we shouldn't expect to find life on Neptune is still strong because it inductively relies on current evidence (in the form of cases of life and non-life) and also abductively provides a rational explanation for why we would expect Neptune to conform to the non-life cases we know about. If we did, however, miraculously find that life, in fact, existed on Neptune, it would merely mean that our explanatory mechanism was flawed and, again, would not invalidate our original premises (facts) we were reasoning from.

Connections to Knowing

As thinking, experiential beings, we use all three forms of reasoning daily, and researchers also rely upon each when doing their work. We use deduction to categorize the world into pre-existing conceptual chunks with absolute certainty. We use induction to predict or infer a conclusion that seems reasonable based on existing evidence without understanding the underlying mechanisms. And we also use abduction to try to explain those inferences in accordance with logical, aesthetic, or otherwise meaningful theories or narratives we have about the world.

Recognizing these different forms of reasoning is paramount for responsible practice because doing so allows us to see the affordances, limits, and dangers of our reasoning approaches. If we are using deduction to apply our predetermined theoretical categories to the world with certainty, then we need to recognize that doing so opens us up to the possibility that counter-instances or contradictions must necessarily call into question or altogether disprove our assumptions. If we are using induction, then we need to recognize that any conclusions we draw will always only ever be our best guesses based on provided evidence and be open to the possibility that we might be wrong in certain cases. And if we are using abduction, then we must also recognize that there might always be other reasonable explanations for phenomena and relationships we are observing that might be equally justifiable given the evidence we are operating from.

In any case, recognizing each of these limits to our reasoning approaches should engender some level of intellectual humility on the part of knowledge-seekers and should help us recognize that reason is not an infallible master to be served but is rather a tool that is applied in various, messy, contextualized ways. In particular, this can make claims of objectivity dubious and always open to refutation and also help us to recognize where subjectivity may be influencing our conclusions.

Learning Check

The primary difference between deduction and induction is that:

- Deduction moves from a law to particulars, while induction does the opposite.
- Induction moves from a law to particulars, while deduction does the opposite.
- Deduction yields a certain conclusion, while induction only yields a likely conclusion.
- Induction yields a certain conclusion, while deduction only yields a likely conclusion.

The primary difference between induction and abduction is that:

- Induction is more certain.
- Abduction is more certain.
- Induction provides an explanation for the mechanics of why the conclusion is likely.
- Abduction provides an explanation for the mechanics of why the conclusion is likely.

Scientific Terms for Truth-Seeking



Pilate saith unto him, What is truth? (The Holy Bible, John 18:38)

So far, we have only discussed the nature and processes of knowing and have wholly ignored the all-important question of whether what we claim to know is actually true. Like Pilate, many cynics or skeptics have essentially thrown up their hands in surrender when confronted with the difficulty of ascertaining truth, and others have intentionally used the difficulty of nailing down truth to surreptitiously short-circuit any truth-seeking endeavor.

Yet, at the end of the day, each of us does seem to care about what is true and what is false, and we spend much time and energy trying to distinguish between the two. Knowing alone isn't enough, because we can certainly know things that are false, so we rely upon mechanisms of truth-seeking and a variety of notions related to truth to help us (hopefully) arrive at it in reliable ways.

True is an adjective that we use to characterize certain propositions or statements, and though people might differ on what they believe to be true or even what truth is, there seem to be some commonalities in how we use these words and what we expect them to mean. For instance, we wouldn't call a proposition true if it didn't reflect our observations or experiences with reality (e.g., "the newspaper says that the weather is very hot, but that can't be true, because it is snowing"). Likewise, we wouldn't call a proposition true if it changed every time we tried to test it (e.g., "this plant was a daisy yesterday and a rose today") or if it was impossible to understand (e.g., "a garfump is a schnerf"). The terms *truth*

and *true*, then, might mean many things, but they seem to at least suggest some essential characteristics of accuracy, consistency, understandability, and exactness.

In various scientific enterprises, we use many terms that we expect to have some level of truth to them or that we hope will help us to arrive at truth in some form or fashion, including facts, laws, theories, and hypotheses. These might also be considered types of knowledge or singular steps toward knowledge. In this section, I will differentiate what these terms actually mean and how they are used in scientific endeavors to help us to better understand how they relate to truth.

Facts

Facts are finite, specific, and observable things, and facts are considered true if they can be universally and consistently observed or measured. The word "fact" carries with it a connotation of truth. Thus, a statement like "it was 103 degrees Fahrenheit in Phoenix on March 20" would be a purported statement of fact that we could either prove or disprove by consulting records of temperatures or observing a reliable thermometer on the day in question. If proven untrue (or if different observations of the phenomenon conflict with one another), a statement ceases to be a fact. Thus, facts are a subset of truth.

Because facts are finite, specific, and contextual, however, they can be misconstrued or misinterpreted as evidence for things that may not be true. In the example above, one might use the single fact that Phoenix was 103 degrees to claim that the weather there is obscenely hot in March, ignoring other instances that place the average temperature at around 77 degrees. By looking at single facts or facts out of context, we can actually draw conclusions about the world that are clearly false, which means that though facts themselves may be readily discernible as true or false, how each fact in isolation relates to truths that are more universal or that actually matter may be difficult to discern. This means that facts alone have limited truth-telling power and that to be useful they often have to be considered in aggregate or as connected with other types of knowledge, such as laws or theories.

Laws

Somewhat similar, laws are finite, specific (often mathematical) descriptions of phenomena or their relationships to one another that are typically used for prediction. For instance, Newton's first law of motion is a finite, specific description of the general relationship between an object and motion. The word "law" also carries with it a connotation of truth but represents a trickier case than "fact," because laws may not be universal, may not be observable in every case, or may rely upon particular conditions to be true that are not explicitly stated in the law. For instance, Newton's laws of motion do not apply to subatomic particles, and various scientific laws (e.g., Boyle's law) require certain variables to remain constant (e.g., number of molecules, temperature). Thus, finding a counter-instance to a law doesn't necessarily make it false but merely means that it is only contextually or conditionally true.

Additionally, one of the major reasons for having laws is that they allow us to make predictions about the world (e.g., "if I push this, it will move"), but if those predictions are not accurate, then the truth of the law is called into question. This means that laws can change or be refined over time, based on emerging evidence (via induction), and that truth claims about scientific laws are, therefore, conditional and contextual. It also means that laws are limited in explanatory power, because they merely describe and predict the observable aspects of phenomena (e.g., their motion) without helping us to understand the "how" or "why" of what is observed (e.g., why gravity works).

Hypotheses

Because we have to be able to evaluate the truth or falsity of purported facts and laws, observation and hypothesis testing are the methods of choice among scientists, constituting the backbone of the scientific method. Hypotheses are proposals that are neither true nor false but that can be tested for falsity. Suppose we want to know if a new reading curriculum influences student standardized test scores. We would start with two hypotheses: (1) the **null hypothesis**, which proposes that the curriculum does not influence test scores, and (2) the **alternative hypothesis**, which proposes that the curriculum does influence test scores. Null hypotheses are always proposed to reflect received wisdom or

current understandings of a topic. In the case of educational interventions, this generally means that the null hypothesis is that the intervention has no effect. Additionally, an alternative hypothesis is also proposed stating the opposite. With these hypotheses, we can then collect evidence or conduct experiments to try to disprove each. As we do this, our assumption is that we should keep the null hypothesis unless there is sufficient evidence to reject it. If we are able to do this, we reject the null hypothesis and accept the alternative, but if we are not able to do this with a reasonable amount of certainty, then we defer to maintaining the null hypothesis.

One important thing to realize about hypotheses is that they are never proven (or shown to be true) but can only be disproven (or shown to be false), which means that we end up accepting hypotheses not because we have proven them to be completely true, but because we have proven other hypotheses to be more false. In other words, our goal with any hypothesis testing is to try to disprove the null hypothesis. If we can disprove it, then we can tentatively accept the alternative hypothesis in its place (recognizing that others might attempt to disprove our alternative hypothesis in the future), but if we cannot disprove the null hypothesis, then we continue accepting it (recognizing that it could nonetheless be disproven with future evidence). In this way, hypotheses and hypothesis testing can only yield truth claims that are tentative (e.g., “we haven’t found any contradictory evidence yet”) about phenomena that are testable, and alternative hypotheses can always be proposed in an attempt to disprove the null hypothesis.

Theories

Theories are quite different from facts and hypotheses but are somewhat similar to laws in that they explain relationships between phenomena. The major difference between a law and a theory is that a theory is more expansive than a law and attempts to describe the “how” and “why” of some observed phenomenon or relationship. An apt, non-scientific synonym for theory would be *story*, *narrative*, or *model* because theories attempt to piece together disparate facts, experiences, reason, and musings in an understandable way. Like laws, theories are also conditional (i.e., a better explanation might arise based on new evidence) and contextual (e.g., evolution by natural selection may not apply in unnatural situations, as in the selective breeding of animals or humans hunting species to extinction), but unlike laws, theories also attempt to use logic and reference to other facts and laws to reasonably explain the processes by which things happen (via abduction). This means that theories, facts, and laws all have the same tentative, limited, and contextual relationship to truth but that theories also have a larger scope and goal of explaining rather than just predicting (as with laws) or verifying accuracy (as with facts).

This means that theories have a more complicated relationship to truth than laws or facts might. Because of their complexity and expansiveness, theories will always have counter-examples or contradictions that they cannot predict. This has led many philosophers of science to argue that theories are never true or false and can never even be proven or disproven, making them different from hypotheses. Rather, theories are adopted or rejected based upon their generative potential (e.g., Lakatos, cf. [Musgrave, 2016](#)), their relative advantage to other theories (e.g., [Kuhn, 1996](#)), or for a variety of irrational or unscientific factors, such as aesthetics or elegance (e.g., [Feyerabend, 1975](#)). We will delve into this issue more deeply in a subsequent chapter, but here it is mainly important to recognize (a) that the term **theory** does not suggest truth or falsity, (b) that a theory is inherently different from facts, laws, and hypotheses, and (c) that there is no movement between these terms (e.g., a hypothesis never becomes a theory, and a theory never becomes a law; a theory is always ever exclusively a theory).

Learning Check

The primary difference between a fact and a theory is that:

- Facts are more true.
- Theories are more true.
- Facts are broader and more explanatory.
- Theories are broader and more explanatory.

The goal of hypothesis testing is:

- To test if the null hypothesis is false.
- To test if the alternative hypothesis is true.
- To test which hypothesis is more true.
- To develop a new theory.

Which of the following terms imply truth (i.e., if a purported _____ is proven wrong, it ceases to be a _____)?

- Fact
- Law
- Hypothesis
- Theory

Truth and Error



Half of a truth is often a great lie. (Benjamin Franklin)

Given these complexities with knowing, knowledge, and truth-seeking, it is not surprising that we all struggle with discerning, proving, and communicating truth. Historically, humans have addressed these problems in a variety of different ways, exemplified in different fields of inquiry, attitudes, faiths, ideologies, and professions.

As an example, the scientific method assumes that objectivity is possible and utilizes inductive and abductive processes to engage in hypothesis testing about the world, using observable facts to falsify or refine existing theories and laws. In contrast, though mathematics might also assume objectivity, it approaches knowledge-seeking in a much more deductive, non-empirical manner through the application of logic and theorems. Other areas of inquiry, however, might reject objectivist aspirations altogether and focus instead on subjectivist or intersubjectivist knowledge by cataloging facts as they relate to or are interpreted by humans.

In any case, these problems of knowing and truth are of paramount importance when moving forward with research because any method we employ will be influenced by our fundamental epistemological beliefs. If I observe a student in a class, then I am assuming that I can objectively understand what they are doing, while if I interview a student, then I am subjectively assuming that their perspectival self-disclosure of their own behaviors, beliefs, and attitudes actually matters and has at least some truthful quality to it.

Each of us must also face the continuous conundrum both in life and in our research of determining when to believe a conclusion and when not to believe it. To help in this regard, scientists approach truth by focusing on errors and error likelihood, categorizing errors into two different types: Type I errors (or false positives) and Type II errors (or false negatives).

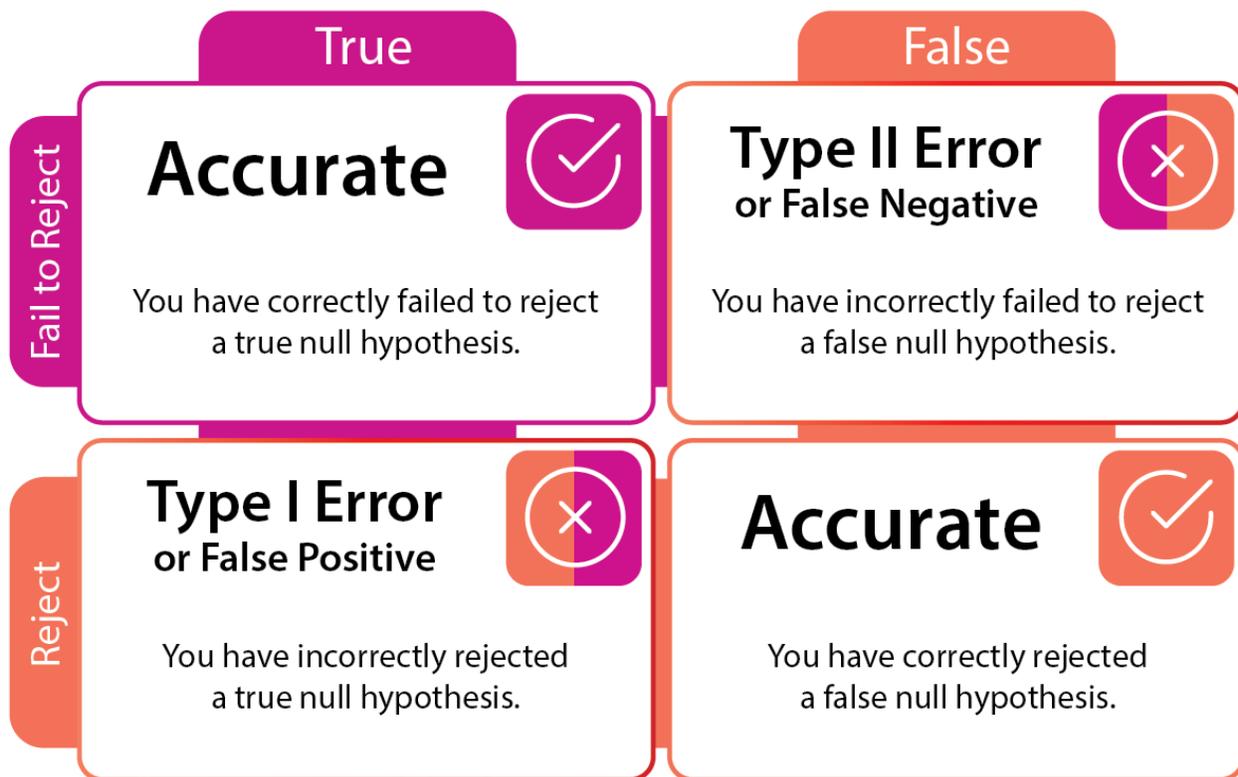


Fig. 1. Type I and Type II Errors as a function of truth and hypothesis rejection

Type I or false positive errors occur when we incorrectly reject a null hypothesis that is actually true. Perhaps we concluded that a new game was helping students succeed at math, but in actuality, the students we tested simply had a natural propensity toward math. Or perhaps we concluded that a different group of students who were performing poorly on a history test didn't understand history well, but in actuality, the students simply were struggling with the language used on the test. With Type I errors, we reject a null hypothesis (and accept an alternative hypothesis) when we really shouldn't have.

Type II or false negative errors, on the other hand, occur when we fail to reject a null hypothesis even when we should have. Suppose I have an intervention that will help students read more quickly, but when I study its effects, I don't include a large enough number of students in my sample to determine significance. I, therefore, might conclude that the

intervention had no effect when it actually did. Or, let's say that I'm studying the effects of school lunch on student performance but only study students from middle-class families. This would likely mean that I wouldn't see negative effects from starvation on students in my sample and might therefore erroneously conclude that school lunch programs have no effect on student achievement.

Both types of errors prevent us from arriving at the truth, and different strategies are used to avoid each. To avoid Type I errors, a researcher might try to be very clear and specific in what they are studying, identifying all factors that might influence results, attempting to control for them, and only rejecting the null hypothesis if they had a preponderance of evidence compelling them to do so. To avoid Type II errors, they might target specific groups or affected contexts, increase their sample size, or refine instruments. Sometimes, these efforts can be conflicting. After all, if I only care about avoiding Type I errors, then I just need to create the most rigid process imaginable for determining truth (approaching every problem as a cool skeptic), but if I do that, then I might be rejecting many things as false that actually are true merely because my mechanism of discernment was too blunt or rigid.

Though the terms *Type I* and *Type II error* are normally only applied to scientific hypothesis testing, this state of affairs should be instructive to us in all forms of inquiry, because we can all make mistakes by either believing things that aren't true or failing to believe things that are true. We could attempt to radically address this by either believing everything, whether or not evidence is provided (and thereby avoid Type II errors), or by establishing unreasonable mechanisms for determining truth, essentially disbelieving everything (and thereby avoid Type I errors). But it seems like no matter what we are trying to learn or how we're trying to learn it, a balanced approach makes sense, and extremes should be avoided. Blind faith and unreasonable skepticism are both extremes, and being a responsible researcher means that we try to untangle truth from error but that we also allow truth to take its hold on us. Almost two thousand years ago Sextus Empiricus, one of the fathers of skepticism, explained clearly that skepticism is not capable of leading to knowledge or truth, only tranquility in the mind of the skeptic (Morison, 2019). Even the staunchest skeptic, upon entering a dark room for the first time, has enough faith in an untested light switch to flip it.

As we move forward in this book, we will continue to reference these matters more deeply within the context of individual paradigms of education research, as each paradigm approaches knowledge, truth, errors, and truth-seeking differently. Some will take an objectivist stance, while others will be more subjectivist. Some will err on the side of avoiding Type I errors, while others will err on the side of avoiding Type II errors. Through it all, it seems that every education researcher is in the business of discerning truth from error, but how we go about doing that may vary in important ways.

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