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Handbook of Abductive Cognition

With 186 Figures and 54 Tables

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Abductive Inquiry and Education: Pragmatism Coordinating the Humanities, Human Sciences, and Sciences

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Abstract

Through its own traditions, research programs, and collaborations with other human sciences, education is a discipline displaying an unbounded potency for advancing human understanding and achievement. Education is a humanistic discipline about culture rather than a scientific field about nature, so it can get classified as a nonscientific discipline because of its inherently historical and social orientation. Narratives about what children should be becoming and how they should be developing are normatively prescriptive, not just naturalistically descriptive. Why then would science serve education? Disciplines such as

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psychology, social theory, and anthropology are relevant to pedagogy because they bridge humanistic disciplines and naturalistic sciences: they are able to be human sciences. They themselves are hybrid blends, so their humanistic knowledge is salient to pedagogy's understanding of the child's learning and the practices of teaching. Although education is primarily a humanistic discipline oriented more to culture rather than nature, pedagogical practice can incorporate knowledge about childhood development, interpersonal communication, intellectual growth, and social integration. Education, while far more than scientific research, thereby joins the human sciences, contributing to scientific inquiry and cultural advancement simultaneously. Due to their similar priorities, education and science make an excellent fit. What is scientific and what is educational are unified at their root by exploratory discovery. With methods exemplifying that spirit of discovery, learners and teaching practices can be studied by the human sciences. Education's humanistic ends are aided by knowledge about the nature of those to be educated.

Keywords

Education · Educational science · Human sciences · Humanities · Science · Abduction · Philosophy of science

Introduction

The world is a patient teacher to a curious species seeking out knowledge. Endless answers shall be given to those asking boundless questions, and that inexhaustibility to nature leaves us both awed and humbled. What the world cannot teach is what we need most to understand: what would be the right questions to ask, to learn even more? We bear responsibility for the inquiries we undertake, so we must attend to what we are doing with our investigations, as closely as we watch nature's doings. Self-exploration accompanies world exploration.

Modern science shines its bright light upon nature, while modernity directs a spotlight of illumination onto us. "What is humanity, that we are mindful of our own education?" Education is a truly human specialty, and all of science without exception is part of humanity's education. This complementary opinion of science is hardly an unfamiliar perspective.

The corollary, that humanistic disciplines can borrow scientific methods and absorb scientific knowledge, sounds less familiar. What about that supposed divide between the sciences and the humanities, keeping both "cultures" deaf and blind to the other? Education straddles that divide and integrates them together at their common root. Not only should science be educational and education should teach science, but their shared mission of abductive discovery connects the humanities, human science, and sciences together in collaboration. This opening principle about discovery is sufficient, for pragmatism, to guide any elaboration of a "philosophy" of education. No theoretical philosophy of education obstructs our inquiry from the

outset, and none will be defined in this chapter, although there is an educational philosophy assembled by its conclusion. To demand a "philosophy" of education up front, prior to empirical inquiry into learning, is to fixate upon an abstract obstacle obscuring the road of practical inquiry.

Education Minding Minds

Education revolves around the experiences of learning and learning well to facilitate ever more learning. Learning that narrows, misdirects, or halts the mind does not deserve the name. Focusing on teaching and learning, we observe a special and solemn space for an important kind of human relationship. Philosophies of education differ over a great deal, but see no reason to disagree here (Carr, 2005; Jackson, 2011; Moore, 2010; Woods & Barrow, 2006). This is a normative situation replete with roles and responsibilities attending to key matters: what should be learned, how does proper learning proceed, and how learning's guidance should be conducted. Education is a human practice, and hence it can be right or wrong and done rightly or wrongly. There is nothing neutral or value-free about education, as it performs its service advancing humanity.

Science as a human enterprise could never be neutral either. Science consists of more than theories and knowledge; it has its methods, values, and norms, too. Depicting science as value-free, alongside education as value-laden, obscures much about both disciplines. The growth of knowledge, along with the development of inquiring minds able to gain knowledge, is as normative and noble as any human endeavor. What science values, education values as well.

On that common field of shared interests, offers of constructive criticism would be expected along with congratulatory confirmations. Sometimes criticism sounds too sharp, as we hear in that head-turning question, "Why is education teaching children all wrong?" Disruptive dictums from science pundits skirt around the heart of the matter: where does science constructively connect with education? Superficial criticism only clouds the important issues. Collaborations between education and science should proceed from a shared nature and purpose, or, if no such basis exists, each one can carry on without interference from the other.

Education has long experience with social forces offering their advice or admonishment. "Why isn't education teaching children right?" is a provocative but ambiguous question, motivated by different intentions behind it. "Why isn't education teaching what is right?" expresses a moral or civic concern. "Why isn't education teaching the right subjects?" instead criticizes what is being taught. "Why isn't education teaching the right way?" challenges the teaching practices.

Science, too, is familiar with getting dragged into social controversies. Science's worldview may be judged as harmful, or helpful, for civic values. Science's knowledge could be assessed as central, or peripheral, for general competencies. Science's expertise might be incorporated as useful, or rejected as irrelevant, for pedagogical efficiencies. Modernity has brought a measure of materialism to our times, but the idea of living in a "scientific culture" remains aspirational. Voices

enthusiastic about science try to be heard over those sounding apprehensive. Upon complaints to the effect that "That education is unscientific," firm priorities have to be set. Shall scientific paradigms be confrontational against, or deferential to, conservative values? Shall scientific areas be secondary to, or replacements of, other subjects? Shall scientific theories be essential to, or optional for, teaching methods?

Among all of these competing demands, education itself should remain the top priority for any society. It must not be regarded as inherently political, exclusory, or mechanical. Treating education as principally about something other than the teaching-learning relationship represents a deeper betrayal of education's mission than any sign of intrusive scientism. Nevertheless, education in general plays many social and cultural roles simultaneously, Education as a public affair does require attention, by the area of *educational policy*. Education as an academic institution calls for oversight with *educational administration*. The core mission of education universally is the responsibility of the discipline of education specifically, where *educational research* is harbored. Where educational research is distorted locally or dictated nationally by policy or administrative agendas, education becomes discordant and somewhat undisciplined.

Discipline starts from putting first things first. Education must embody what is human, to be broadly humanistic as anything else about culture, and duty-bound to advance learning for its own sake. Teaching only sacrosanct ideals deprives minds of comparing and testing values. Teaching only certain subjects to the exclusion of others prevents minds from appreciating a wide variety of endeavors. Teaching in fairly restricted ways limits minds to similarly constrained ways of thinking. Genuine education not only teaches; it teaches in ways that foster ever-more learning and the sure growth of knowledge. Learning for its own sake has but one other devoted ally among all the cultural forms and social institutions ever invented: science.

Minds should become explorative, experimental, expansive – with that mental growth in focus, the operational mission to education is coming into view. An undisciplined or debilitated education, less than fully capable of facilitating further learning, cannot do justice to that special learning-teaching bond. Mentality and its growth must possess its own inherent value and intrinsic justification. No doubt that is why all areas of human achievement, particularly science, unfailingly prize the mind – while any number of social forces try to manipulate minds.

Experiential Education and Scientific Inquiry

Science, like all exploratory discovery, built upon that foundation of education embedded at the core of human culture. It would be foolish for scientists to think that they have no need of learning and sound insights into good learning. If knowledge does not come from learning, by what process could knowledge ever enter a mind? Mystical and mythical illumination were left to religion when science gained its independence from theology. In science, learning from exploratory experience surely counts as learning.

The purpose of thinking is inquiry, for the one who is underdoing the learning processes. This is the essence of all education, in whatever form and format. In the words of John Dewey:

> To say that thinking occurs with reference to situations which are still going on, and incomplete, is to say that thinking occurs when things are uncertain or doubtful or problematic. Only what is finished, completed, is wholly assured. Where there is reflection there is suspense. The object of thinking is to help reach a conclusion, to project a possible termination on the basis of what is already given. Certain other facts about thinking accompany this feature. Since the situation in which thinking occurs is a doubtful one, thinking is a process of inquiry, of looking into things, of investigating. Acquiring is always secondary, and instrumental to the act of inquiring. It is seeking, a quest, for something that is not at hand. We sometimes talk as if "original research" were a peculiar prerogative of scientists or at least of advanced students. But all thinking is research, and all research is native, original, with him who carries it on, even if everybody else in the world already is sure of what he is still looking for. (Dewey, 1916, pp. 173–174)

It is unnecessary to advocate Dewey's entire philosophy of education to acknowledge the sensible point about learning made here. Dewey had an enormous influence on progressive educational theory (Darling & Nordenbo, 2003), and his teacher-with-learner approach serves as a counterbalance to curriculum-centered paradigms on the one side and child-centered pedagogies on the other (Noddings, 2015). His broad views on education never stray far from his tight focus on thinking, problem-solving, and learning from the trials of experience.

Why would science be distanced from education? Empirical sciences could not plead ignorance of the methods behind their discoveries while taking credit for those successes. Scientific methods are fundamentally methods of experiential learning, or else they have nothing to do with knowledge. We need not rehearse outdated debates between empiricism and rationalism to understand that the sciences surmount that standoff by fruitfully combining empirical observations with reasoned inferences in their complex methodologies. Science deserves all due credit for its numerous sophisticated methodologies, carefully crafted for the many domains of diverse fields and subfields of inquiry. Reliable methodology conducive to knowledge is hardly alien to education.

Let us then seriously ponder how science is education *and* education is scientific. This thesis for deliberation is not merely that "science is educational" or that "education includes science." Announcing their rooted unity presents a truly radical thesis, exposing to our view their deep common root. Their superficial apprehensions will not delay our excavation. Education, as a humanistic discipline, often exhibits anxieties and antipathies toward what is regarded as scientism. Science, for its part, would not surrender its hard-won independence just to be submissive to humanism. Both sides need to relax their defensiveness. Neither values-free scientism nor values-laden science is our objective. Worries over reductionism or relativism are premature until the territory around education and science has been adequately scouted and surveyed.

Deeper commonalities have to be investigated, to get past hasty misconceptions. A widespread notion about education thinks that it only transmits established knowledge, while science acquires new knowledge. Science education, for instance,

makes complete sense from a scientific standpoint, supplying knowledge that education conveys. This preconception treats education as just *teaching* lessons for dutiful learners, while science is *testing* ideas for daring explorers. Didactic instruction fits that caricature for education, at most. Such an antiquated view of education hardly comports with science's respect for modernized empiricism. Let us all be sound empiricists at last.

Education in its refined meaning has everything to do with active learners trying out ideas new to them. Experiential learning is sounder than rote learning. Educational research accordingly explores the possibilities to dynamic learning in all its forms and formats. Experiential learning is not synonymous with solitary learning. Suitably directed, education can guide learners through processes of comparing and testing their own ideas as well as those of others and encourage inquisitive activities calling for group participation. Science applies its methodologies within group efforts of comparatively testing ideas of explorers through guided research programs. That description makes a fine fit with the conception of empirical and experiential education. Education and science are, from their root, the same flourishing and flowering of human mentality.

From any learner's perspective, acquiring knowledge is voyage of novel exploration and discovery, just as the scientist's experience of performing scientific inquiry is exploratory discovery too. Still, voices keep insisting on science's independence from education. We will be reminded that instructional settings provide teaching guidance. Group guidance is indeed crucial, we can reply. Does the scientist confront nature alone, out beyond society and all social institutions? Just the opposite: organized scientific communities together establish confirmable knowledge. We will also be reminded that educational instruction presumes that most everything to be learned is already well-confirmed and reliably known. Again, we can reply, any scientific field relies on an ample storehouse of established knowledge from past investigations and theoretical advances.

We will next be told that educational practices, unlike scientific programs, depend on multiple disciplines. Indeed, education blends traditions of pedagogy with knowledge from allied disciplines such as developmental and abnormal psychology, sociology, and organizational studies. Yet when we turn to look at any scientific field, its supportive subfields and neighboring fields contribute knowledge and methods. The field of cellular biology would be making little progress absent the participation of biochemistry, molecular biology, and genetics or without collaborations with physiology and evolutionary biology.

Parallels are only mounting between scientific inquiry and experiential education. Scientific independence from education is, so far, looking less and less plausible. There must be sound methodology for experiential learning and discovery, or else nothing about science or society makes sense. The sciences regard their methodologies as highly refined and specialized, and too complex for application in educational settings. That is a valid distinction, only confirming the general standpoint urged here about a shared science-education heritage.

There is much that science does that cannot appear educational, and much occurs in education that doesn't seem particularly scientific, but their common

core of experiential discovery plays its essential role nonetheless. Elementary and secondary instruction introduces elements of empirical and experimental inquiry, and then scientific fields instruct their college majors and graduate students in advanced methodologies.

Culture in Nature

Admitting the core heritage behind by science and education, the path ahead may yet diverge. They are distinct fields, after all. A fact-value dichotomy might send them in divergent directions. In order for science to make theoretical discoveries, it strives to leave the normatively human behind as it neutrally postulates natural entities, energies, and laws that exist anywhere at anytime. Education places the normatively human world out in front, proceeding for the sake of that particular world and that world's future. Education as a discipline must contain a historical and historicist component, even as it conveys its ongoing work into the future. Its pedagogical practices developed within humanity's cultures to perpetuate those heritages, and nothing about pedagogy makes sense outside of that genealogy.

Two divergent objectives now open up before us. What education, along with other humanistic disciplines, wants to comprehend is what being human can become. What science seeks to understand is what being natural must be. This is an important difference; whether there is also an ontological dichotomy is a meta-methodological matter for philosophical reflection. Both the humanities and the sciences deserve a careful hearing. What can humanity become, in light of the way that we have gotten to where we are so far? Agency, opportunity, and liberty are presumed values with the asking of that humanistic question and can't be omitted in any sensible answer. What must nature be doing, in light of the way that we have observed events around us so far? Energy, regularity, and conditionality are presumed categories with the asking of that scientific question and won't be omitted in any reasonable answer. Philosophies do not fail to note this divergence of objectives and presuppositions, while disagreeing over their ontological and metaphysical implications. Some philosophies formulate the compatibility or even convergence of these objectives, reconciling the human with the natural. Other philosophies magnify their incompatibilities, defining the human and the natural in categorically contrary ways.

Education can be easily classified as a nonscientific discipline because of its inherently historical and social orientation. Narratives about what children should be becoming and how they should be developing are normatively prescriptive, not just naturalistically descriptive. Why then would science serve education? Disciplines such as psychology, social theory, and anthropology are truly relevant to pedagogy because they bridge humanistic disciplines and naturalistic sciences: they are able to be *human sciences*. They themselves are hybrid blends, so their humanistic knowledge is salient to pedagogy's understanding of the child's learning and the practices of teaching. Although education is primarily a humanistic discipline oriented more to culture rather than nature, pedagogical practice can incorporate

knowledge about childhood development, interpersonal communication, intellectual growth, and social integration. Education, while far more than just scientific research, thereby joins the human sciences, contributing to scientific inquiry and cultural advancement simultaneously.

The internal struggle within education over the question, Shall education be a culture-oriented discipline about comprehending *what is human* or a science-oriented field about understanding *what is natural*, can be quelled and dispelled. It is no contradiction in terms for education to focus on what should be naturally human: how each child's intellectual capacities should get developed toward bountiful results. It would be unnaturally wrong to neglect a child's thinking capacities and normally right to administer sound teaching practices. Nurturing and naturing are united here, so long as education is well-informed about the import, efficacy, and impact of those practices.

Education can be scientific to the extent that it views its body of time-tested pedagogical practices as opportunities for further investigation, trial, and adjustment, even as education's pedagogical goals always transcend science's purview. This historical co-development, between the improvement of practices which in turn enhance cultural ends, leaves nothing unaffected or unchanged while generation and after generation receives its education. How children are taught now is a lesson telling culture how its adults will be able to think.

Philosophy of education need not follow the academic tendency to keep fields apart and erect rigid dualisms between disciplinary categories, goals, and methods. Philosophy itself can examine the historical-cultural nature of education alongside the experimental-natural purpose of science, discerning their shared commitments and methodologies.

Education, like history, social theory, psychology, and anthropology, do not number among the sciences, intrinsically or in their entirety. Their missions revolve around agency, not causality, and their methods and ethics forbid fully controlled experiments on humans. (How would experimenting with control groups who are denied such things as autonomy, nurturing, opportunity, or security be allowed to proceed?) However, the portability and adaptability of many scientific methods allows nonscience disciplines to include selected scientific phases. History can take advantage of selected criteria for factual validity and explanatory adequacy. The amenability of social theory to observational and statistical methods allows sociology to flourish. Experimental psychology can use correlative statistics and control groups. Anthropology heeds the counsels of scientific objectivity while conducting its investigative and comparative inquiries. Scientific investigations are evidently educational for humanity's ways no less than they educate humanity about nature's ways. What ontological chasm still divides the human from the natural, to keep humanistic learning far away from naturalistic knowledge?

Four proposals have been advanced so far. (1) What is scientific and what is educational are unified at their root by exploratory discovery. (2) Education is a humanistic discipline about culture rather than a scientific field about nature. (3) Learners and teaching practices can be studied by the human sciences. (4) Education's humanistic ends are aided by knowledge about the nature of those to be educated.

Proposition (1) is met with the challenge that the methods of scientific experimentation are very different in kind from the procedures of learning discovery. This challenge can be satisfactorily answered. Proposition (2) is accurate enough, although answering the first challenge, revealing the core logic of abduction shared by scientific and educational discovery, explains why humanistic disciplines cannot match the experimental powers of scientific fields. Proposition (3) is met by the criticism that the notion of a "human science" remains obscure, since science yields necessary universal laws useless for the humanistic disciplines' respect for contingency and freedom. That challenge is answered by pointing to historical sciences (such as geology, paleontology, biology, and archaeology) which appeal to neither universal nor chancy explanations. Biology is the key to defending (4) from objections. The cultured nature of the human learner has resulted from evolution, so the normativity of culture is a natural object of study by the humanistic sciences.

The *nature* of humanity is to be intelligently cultural. Culture expresses that freedom of the ongoing discovery of human potential. While more creative than controlled, humanistic discovery benefits from scientific counsels about humanity. While scientific in methods, human sciences explore how humanity has been self-created and continues to self-create. Science is not alien to the historicity of cultural endeavor, as a component of that human project of exploration. The spirit to humanity lies in that distinctive life of the bio-culturally coevolved human animal.

Abductive Inquiry and Knowledge Discovery

Are the methods of scientific experimentation so different in kind from the procedures of learning discovery? We have already left behind didactic repetition for rote memorization. We can also set aside inferior ways to learn from getting exposed to a heterogenous mass of supposed facts or from getting invited to accept conclusions deduced from assumed premises. The former method is appropriate for making acquaintances with natural curiosities, and the latter is essential in geometry and mathematics. Beyond those delimited stages, acquiring useful knowledge has to be interactive rather than passive.

Learning that engages the learner's own queries and develops the learner's critical faculties must be exploratory: acquired knowledge opens up further questions for exploration by empirical eyes and rational minds. Are we only contemplating education with this conception of learning? Dewey has a basic definition for science in mind to offer us too: "science signifies, I take it, the existence of systematic methods of inquiry, which, when they are brought to bear on a range of facts, enable us to understand them better and to control them more intelligently, less haphazardly and with less routine" (Dewey, 1929/1984, pp. 3–4). Learning is learning, at any level or stage of progress.

Exploratory learning is surely enhanced by suggestive teaching. We need not exalt "self-guided" learning, the sort of inadequate psychology that pragmatism warned against, in order to keep up with the oft-heard contention that science needs no teacher other than nature itself. Depiction of the lone scientist eliciting nature's

secrets is a romanticized image at best and a crude caricature at worst. Competent participants offering their knowledge, suggestions, and criticisms surround any research scientist. Research teams do have to eventually answer to nature, but so does any exploratory learner desirous to learn something directly rather than at secondhand. Motivationally, who is the cutting-edge experimenter but a proficient learner once again having a long look at nature?

Methodologically, no empirical inquiry should be solitary, since the vagaries of cognitive bias and prejudice require communal compensations. Co-informants (any information sources whether natural or human) may be in the past, in the present, or mostly in the future. If informants are no longer here but only in the past, the inquirer must adopt their perspectives and viewpoints, on matters thus taken as *historical*. If co-informants are present and accessible, the inquirer can solicit their information, on matters thus taken as *expositional*. If instead co-informants will mostly exist in the future, the inquirer can conduct trials that are replicable, on matters thus taken as *experimental*.

All three methodological orientations – whether historical, expositional, or experimental – are implemented and accomplished through abductive procedures of inference (Magnani, 2010; Aliseda, 2017; see Shook, 2021a for more references). The founder of pragmatism, Charles Peirce, places the burden upon abduction for pursuing and finding explanations:

> Abduction merely suggests that something may be. Its only justification is that from its suggestion deduction can draw a prediction which can be tested by induction, and that, if we are ever to learn anything or to understand phenomena at all, it must be by abduction that this is to be brought about. (Peirce, 1934, pp. 171–172)

Humanistic disciplines attempting to be exploratory and explanatory cannot avoid the rigors of abductive inference.

The discipline of history, as the most historical of inquiries by definition, is inquisitive, selective, and organized, but those are low standards to meet. Exemplars of far-from-scientific history are historians composing a compelling tale (the literary historian), a morality lesson (the hagiographical historian), or a vindication epic (the ideological historian). For the investigative historian, sources are indispensable but not infallible or unchallengeable. Records from sources offer viewpoints upon their topics (they are not entirely subjective), so higher objectivity lies in the collection and colligation of many source records and material traces. This historian develops a hypothesis that can be put to trial, revolving around a proposal, such as "Rome's civic instabilities were behind Caesar's dictatorship and swift assassination," that may be tested against further information and interpretations (Collingwood, 1946). The scientific historian refines investigations further, heeding the naturalistic worldview and consulting allied human sciences about the past, such as antiquarian forensics, paleography, archaeology, and geography (Diamond & Robinson, 2010; Roth, 2012).

That abductive process also lies at the heart of the two remaining modes of investigation: expository and experimental.

While co-informants are presently accessible, exploration takes a predominantly expository form. The inquirer can solicit interviews or consultations. Broadly social influences and forces are amenable to investigative methods of the social sciences (Backhouse & Fontaine, 2010). Interviewing enough people about a town's rising prices, as a sociologist, journalist, or pollster may undertake, offers some qualitative insight into local concerns. Quantitative investigations follow in their wake, scalable up to any desired scope. Calculating an entire nation's rate of monetary inflation requires the quantitative tabulation of vast amounts of data collected by fairly representative sampling across the country. The resulting expositions from extensive investigation, whether journalistic or economic, remain improvable with enough resources. Journalism's "first draft of history" is combined with related sociological information about mass behaviors, customs, institutions, and the like, to sketch a general portrait which is then available for further testing against the still-growing collection of insight and information. The efforts of economics to fine-tune its measures of fiscal and market activity can be especially relentless and ceaseless.

A paradigm form of expository investigation is the crime investigation. The accused and witnesses are questioned, crime scene clues are forensically analyzed, and contextual conditions surrounding the crime are registered. Like the historian, the detective formulates a reasoned account to explain the unfortunate event, while minding the sociological adage that human affairs are so complicated that alternative accounts have to be considered and compared. The maximally coherent account is probably closer to the truth, especially if it survives impartial scrutiny (e.g., by judges and juries). Sherlock Holmes' fictionalized acuity relied on abduction more than deduction or induction, although his swift capacity for contrasting multiple guesses by their deduced consequences, and then spotting the singular clues eliminating all but one explanation, disguised his abductive powers (Carson, 2009).

A detective's criminal investigation is akin to a trial and serves as an opening phase to a potential criminal trial. "If the accused really committed the crime, then further consequences of both the criminal's behavior and the crime scene should become observable under the right conditions." Rarely do the initial facts determine responsibility. They merely set up the opportunity to explain that event as the outcome of a chronological sequencing of conditioning events that allowed that particular event to happen. More evidence must be experimentally gathered (forensics, interviews, etc.) to test various hypotheses about the responsible causes for that crime. It is true that the "crime event" is treated as a particular event with its own contingent conditionings and causes, rather than as an "individual" event that must occur whenever necessary conditions are lawfully satisfied. That is because a "crime" is a sufficiently complex event, so inquiries into its "lawfulness" are impractical, and a "crime" is an event involving humans so it bears particular (indeed, unique) interest in its own right. For sociology, by contrast, individual deeds are only noticed and measured so that mass statistics about generic kinds of crime can be metrically accumulated. In sociology, a crime is still an event, but it is now an "individual" event to be treated and explained as an individual case within a general pattern of mass social action (Hester & Eglin, 2017).

However exploratory, a detective's investigative methods remain constrained by an inability to conduct a highly controlled experiment. It is impossible to recreate situational conditions prior to a crime, human behavior is hardly lawful even under ideal conditions, and neither the suspects nor the victim can be "reset" to initial psychological states as they were prior to the crime. It is impossible to learn if the accused "would have surely done that crime at that time in that same way." All the same, investigations can conduct partially controlled experiments. That crime was in the past, but most of its components did continue on, and many effects from those components continue to exist to the present time. That is why the investigation must happen quickly, while conditions are fresh and clues haven't dissipated (Fisher & Fisher, 2012). If too much time passes, looking for additional evidence will seem more like an expedition than an experiment. "Cold cases" can still be investigated (Adcock & Stein, 2014), but that sort of expeditionary quest is more akin to an animal hunt down a trail gone cold.

The third mode of discovery, the experimental, is undertaken when co-informants for the inquiry are mostly in the future. An analogy from Peirce illustrates this collective intelligence: "The scientific world is like is like a colony of insects in that the individual strives to produce that which he himself cannot hope to enjoy. One generation collects premises in order that a distant generation may discover what they mean" (Peirce, 1958, p. 87). For Peirce, a community of scientific inquirers can be indefinitely extended into the future, no matter how many visible geniuses stand among us now (Shook, 2021b). Historical and investigatory disciplines can be "scientific" in this minimal sense, seeking empirical truths through methods amenable and answerable to similarly scrupulous and honest researchers. However, with experimental inquiry, Peirce's vision from the heights of scientific inquiry looks to the far future.

Indirect communication with people that one hasn't met and won't ever meet has to take the form of exacting experimental design and precise data collection. Controlled experiments to test an abductive hypothesis have to be closely replicable so that future confirming results are repeatable and comparable. The general way that a crafted experiment is reproducible by generic experimenters, anywhere and anywhen, is essential to the postulate's credibility in the long run. The logic of abductive discovery requires this prolonged reach of experimental inquiry, so that weaknesses to poor hypotheses are eventually exposed. Peirce's understanding of science expects future inquiries, if rigorously scientific in character, to converge in the very long run (over thousands or millions of years, if necessary) toward an answer: "Inquiry properly carried on will reach some definite and fixed result or approximate indefinitely toward that limit" (Peirce, 1932, p. 485). His definition of truth for science (not for "truth" in other contexts) is this: "The opinion which is fated to be ultimately agreed to by all who investigate, is what we mean by the truth" (Peirce, 1934, p. 407). Whatever cannot satisfy these two conditions of character and convergence cannot count as genuine scientific inquiry, since it will lack credible objectivity and realism. The humanities are not expected to satisfy this scientific idea of truth, for their missions are focused on comprehending and

explicating human practices, institutions, and areas of cultural achievement. The human sciences elevate their aims toward explanation, prediction, and direction.

Differences between investigative and experimental inquiries can be exaggerated. Physics is often held up as "genuine science" because it conducts replicable controlled experiments and validates many hypotheses to near-certain degrees. Knowledge from partially controlled experiments can be obtained, without question, and many fields offer practical advice about statistical correlations. For example, clinical trials purporting to find the efficacy of a new drug include "control groups" cannot fully control all confounding variables. Determining true mechanisms of bio-physiological action lies beyond the capabilities of the most rigorous trials, which are at best suggestive about sure causes to guaranteed effects (Machin et al., 2021). Clinical trials are abductive experiments on human subjects, but they are more investigational than strictly experimental like chemistry or physics.

Nine Modes of Exploratory Discovery

We have distinguished three procedural types: the empirical, investigative, and scientific. We then distinguished the historical, expository, and experimental orientations to inquiry. A total of nine modes of exploratory inquiry, represented in Table 1, are given with the nine boxes, each representing a phase of abductive inquiry as an element of discovery.

Humanistic Disciplines

Humanistic disciplines are not sciences, focused instead on understanding and explaining the capacities and results of human thought, agency, and activity. Factual evidence is not dispositive here; what ought to be enjoys preeminence over what happens to be. Exploring the possibilities of human potential is the supremely important sort of exploration, devoted to creative discovery, not empirical discovery. Each discipline is highly selective about the character and salience about "evidence" relevant to its normative paradigms. Exemplars of humanistic disciplines are philosophy (inclusive of logic and ethics), history, social theory, theology, political theory, economics, and mathematics.

The nine discovery modes display the predominance of abductive hypothesizing and testing over deductive and inductive methods. Deduction by itself only confirms whatever is already believed, and that is why humanistic disciplines often fail to rise above traditional customs and parochial values. More imagination is necessary. Induction yields an enlarging evidence base to improve our acquaintance with ourselves and nature, but its meanderings only hint at deeper patterns and causes. Still more imagination is needed. Fully methodological inference (abduction) is far more explanatory, by postulating underlying explanations only revealable through experimental trial.

Table 1 Nine modes of inquiry

Type of informants Basis of evidence	Past informants for **historical narration**	Present informants for **dispositive exposition**	Future informants for **scientific experimentation**
Empirical evidence	**Mode One** Respects all available sources that are able to pass checks for credible authenticity and mutual consistency	**Mode Four** Interrogates witnesses and collects evidence in order to discern which hypothesis can acquire the most plausibility	**Mode Seven** Accumulates and categorizes evidence so that future inquiries can rely on its patterned and predictive organization
Investigative evidence	**Mode Two** One, plus: Imposes interpolations and interpretations to reach for maximal coherence and singular chronology	**Mode Five** Four, plus: Consultations with recognized experts, but their judgments are not necessarily taken as definitive	**Mode Eight** Two and Seven, plus: Applies controlled methodologies ready for scrutiny and replication by further investigation
Scientific evidence	**Mode Three** One and Two, plus: Incorporates expertise from allied scientific fields and omits nonnaturalistic events	**Mode Six** Five, plus: Relies on knowledge from allied scientific fields and ignores nonnaturalistic ideas	**Mode Nine** Six and Eight, plus: Experiments fully control conditions for repeatable consistency with future science

Humanistic disciplines expanding their interests into explanation, prediction, and control, whether dealing with the natural or human realms, venture beyond the historical and exposition modes into scientific modes. Relationships among humanities and sciences have varied widely, from cooperation to conflict (Slingerland & Collard, 2011; Bouterse & Karstens, 2015). Conflict over methodological principles occurs periodically, but there is no need to regard that contest as permanent or irrevocable. So long as the nine discovery modes are discriminated and applied, jointly humanistic and scientific inquiries can be charted without confusion.

Selected examples of fields for each of the nine modes are listed to illustrate distinctions found among them.

The Two Historical Modes

Mode One. Herodotus-Style History, Ecclesiastical Theology, Oral Narrative Recording, Journalistic Reporting.

Mode Two. Polybius-Style History, Rankean-Style History, Intellectual Biography, Political History, Systematic Theology.

Let us pause to explore modes of historical investigation. “History” comes from the Greek word for “inquiry” into actual matters leaving evidence for an

inquirer to look into. An honest inquirer must be guided by sources having then-contemporary or near-contemporary perspectives, rather than blind credulity about hearsay and legend. Selectivity is necessary for the organization of empirical history, as the work of Greek historian Herodotus displays, but that is still a low standard to meet. For the investigative historian, such as the Roman historian Polybius, sources are indispensable but not infallible or unchallengeable. There is a methodological expectation of chronology and consistency among candidate facts, with a minimization of partiality and prejudice. The scientific historian (Mode Three below) refines investigations further, heeding the naturalistic worldview and consulting allied fields about past matters, such as literature, antiquarian forensics, paleography, and archaeology.

The Two Exposition Modes

Mode Four. Ecclesiastical Inquisition, Crime Investigation, Investigative Journalism, Public Polling, Ethnography.

Mode Five. Canon Jurisprudence, Civil Jurisprudence, Government Inquiry, Foreign Intelligence.

The Five Scientific Modes

Mode Three. Chronological, but hard evidence is left to more scientific fields.
Human Sciences: Scientific History, Antiquities Authentication, Art Authentication.

Mode Six. Investigatory and diagnostic, but experimentation is in the hands of other scientific fields.
Human Sciences: Digital Forensics, Forensic Criminology, Forensic Anthropology, Forensic Authentication, Abnormal Psychology, Psychiatry.

Mode Seven. Exploratory and modestly predictive, but experimentation goes little farther than events naturally or socially provided.
Natural History: Geography, Ecology, Linnean Biology, Botany, Zoology, Anatomy, Animal Behavior.
Human Sciences: Human Physiology, Clinical Psychology, Sociology, Demographics, Cliodynamics, Linguistics, Educational Research, Anthropology, Epidemiology, Political Science, Economics.

Mode Eight. Moderate control over experimental conditions, more for identifying conditions beyond human control.
Historical Sciences: Cosmology, Astronomy, Geology, Earth Sciences, Evolutionary Biology, Paleontology, Paleoarchaeology, Materials Analysis.
Human Sciences: Archaeology, Clinical Medicine, Experimental Psychology, Neuroscience.

Mode Nine. High control over experimental conditions, more for identifying causes amenable to human control.

Physical Sciences: Mechanics and Dynamics, Classical Physics, Quantum Physics, Chemistry, Minerology, Metallurgy, Materials Science.

This organization is not about the subject matter of a discipline, but its methodological resources.

Scientific fields among the earth and life sciences in Mode Seven have to be more exploratory and expeditionary than strictly experimental. Fields descended from traditions of natural history such as botany, zoology, geography, geology, and paleontology are obvious illustrations. To discover why a particular thing or event came to be, scientists will plan and execute investigations and explorations, but past and vast natural powers controlled what happened. Mode Eight allows for greater control over experimental design and execution. Archaeology and neuroscience, for example, share the capacity for modest control over experimental inquiry, by meticulously conducting earthen excavations or by painstaking analyses of neural tissue. By contrast, to precisely determine how a kind of thing or event always comes to be, the physical sciences in Mode Nine are able to test hypotheses with rigorous and replicable controlled experiments.

Educational Research

Education as a discipline could be, and has often been, scaled back to history of education or to educational policy. Historical studies can summarize careers of pedagogical movements, recount teaching and learning experiences, lament inequitable access, praise respectable pioneers, point out correlations among social and civic factors, and identify enduring instructional methods (cite standard books on education, etc.). Humanistic disciplines do have normative standards and ideals to uphold. These studies in education can discern, debate, and decry the variable ways that different societies have valued learning and invested in teaching. Turning the spotlight onto national affairs, education can undertake inquisitive investigations in order to broadcast exposés, make policy indictments, and back political reforms.

As broadly as education must sojourn, it avoids becoming undisciplined by aiming higher. For a human-centered discipline beholden to best practices both today and tomorrow, it is that teaching-learning space that must remain primary, so practical problem-solving cannot be secondary, and educational research can fulfill that commitment (Baez & Boyles, 2009; Biesta & Burbules, 2003). Striving to be more than a collection of customary traditions, current exemplars, revered paradigms, or ideological agendas, disciplined education additionally respects inquiries assignable to scientific Modes Six and Seven. Educational research cannot attain the status of Mode Eight science, unlike experimental psychology and neuroscience, although education should consult their well-established theories without imitating their techniques. Mode Nine science, by requiring fully controlled and exactly repeatable experiments, is impractical for human subjects and beyond education's reach.

Overall, it is now clear that educational research cannot be reduced without remainder to any number of physical, biological, physiological, or brain sciences. Cooperation, not reduction, opens up the path in front of education. Quality research can be accomplished, including both student-centered and teacher-led research, so long as any "laboratory" for education revolves around living educational spaces. Displays of science-aversion out of loyalty to an idolization of disciplinary independence cannot serve learners or teachers.

By joining the human sciences, disciplined education and educational research have plenty of good company for collaborations and alliances (Furlong & Lawn, 2010; Bridges & Thompson, 2011; Peters et al., 2014; Bridges, 2017). Sociology, ethnography, psychology, organizational studies, communication studies, technology studies, and related disciplines will never be sciences either, at most attaining to human sciences. Human sciences easily lend themselves to interdisciplinary investigations and experimentation so long as they are generous with their expertise.

Scientific research in the area of educational research, like research in the human sciences generally, has been a controversial topic for decades. Key issues were present at the birth of education as an academic discipline, and they continue to carry great weight (Lagemann, 2000; National Research Council, 2002, 2012). Education has plenty of company with neighboring human sciences also digesting roles for scientific inquiry. For example, James Grand and colleagues who advised the Society for Industrial and Organizational Psychology on research practices have formulated criteria for "robust science" in the human sciences: research that is relevant, rigorous, replicated, accumulative and cumulative, transparent, open, and theory oriented. In their words:

> … a robust science is one in which activities throughout the entire scientific enterprise are conducted with the intention of producing positively impactful and relevant knowledge"; "the rigor of a science is reflected in the extent to which its core concepts and their relations are operationalized with precision, and the methodologies used to collect informative observations are accurate and appropriately aligned with the analytical techniques used to infer meaning from those observations"; "the replicability of [science] findings … pursues efforts to gather repeated (i.e., replicated) observations of the mechanisms and relationships among core concepts and processes of human behavior, and that these efforts are made accessible in the corpus of scientific evidence"; "the strength of scientific understanding and inference is enhanced through careful vetting, deliberate calibration, and compounding multiple observations into an integrative whole. … the pursuit of cumulative knowledge is reinforced by adopting an appropriate degree of intellectual skepticism toward novel propositions and appropriately adjusting those beliefs on the basis of accumulated evidence"; "a robust science [is] one in which transparency and openness are embraced throughout the research process and scientific system. Activities that embrace these principles include more complete disclosure of data, materials, analyses, and hypotheses to the scientific community; promoting publication practices in which important questions answered well have a place in the literature regardless of results; and creating accessibility to the research process at all stages of production"; "a robust science is simply one in which its scientific pursuits contribute to explanation and 'refinement of everyday thinking' by replicating, bounding, revising, falsifying, and, when appropriate, advancing new claims. (Grand et al., 2018, p. 11, 12, 13, 14)

Going further, Grand et al. emphasize that theories searching for confirming data is not explanatory science – robust science run experiments searching for data *disproving* hypotheses:

> . . . robust science is 'theory oriented' (not theory driven or theory dependent) and promotes this tenet by describing, evaluating, and refining explanations. Genuinely accomplishing this goal requires research that reflects quantitative and qualitative methodologies across the full range of inductive, deductive, and abductive approaches. . . . The rightness of a theory is not determined by the clarity of its arguments or through formal logic but by subjecting its claims to the gauntlet of empirical investigation. A science that strives for precise theories purposefully subjects its explanations to an increased "risk" of falsification to determine the level of confidence that should be placed in proposed relationships. (Grand et al., 2018, pp. 14–15)

This burden on theory comes from a scientific respect for abductive problem-solving and discovery, not the outdated "top-down" approach of earlier eras. Expecting education to become a theoretical science of its own at one leap only revisits outdated epistemological and falsificationist philosophies (Rowbottom & Aiston, 2006; Rowbottom, 2014).

As philosophy well knows, in the arena of empirical explanation, clever fits between a neat theory and its preferred data prove little. Education's humanistic mission is not so permissive that it deserves exemption (Carr, 2006). Although positivism and foundationalism are now history, the fashionable dismissal of "pure" data is no license to deny that good data can't drive out bad theory. A theory shouldn't dictate its own observational support. That is why a mixture of methods and experiments conducted by trusted lower-level theories, including those from fields neighboring education such as psychology and sociology, supplies independently collected information (Gorard & Taylor, 2004; Niaz, 2008; Biesta, 2010; Hall, 2013). Hypotheses meriting credibility are those able to survive both serious rivals and plenty of reliably collected data from multiple sources.

For educational research, a similar statement of robust scientific criteria was provided in a major piece of American legislation about educational policy, the "No Child Left Behind Act of 2001," where scientifically based research is outlined:

> (i) employs systematic, empirical methods that draw on observation or experiment; (ii) involves rigorous data analyses that are adequate to test the stated hypotheses and justify the general conclusions drawn; (iii) relies on measurements or observational methods that provide reliable and valid data across evaluators and observers, across multiple measurements and observations, and across studies by the same or different investigators; (iv) is evaluated using experimental or quasi-experimental designs in which individuals, entities, programs, or activities are assigned to different conditions and with appropriate controls to evaluate the effects of the condition of interest, with a preference for random-assignment experiments, or other designs to the extent that those designs contain within-condition or across condition controls; (v) ensures that experimental studies are presented in sufficient detail and clarity to allow for replication or, at a minimum, offer the opportunity to build systematically on their findings; and (vi) has been accepted by a peer-reviewed journal or approved by a panel of independent experts through a comparably rigorous, objective, and scientific review. (quoted from Baez & Boyles, 2009, p. 7)

These sorts of criteria for robust scientific research, typical across the human sciences, are entirely appropriate for Mode Seven science and set minimum standards

for Mode Eight science. Educational research benefits from its own implementation of those experimental modes (Yates, 2004; Kincheloe, 2004; Lodico et al., 2010; Smeyers & Smith, 2014) and from its incorporation of knowledge acquired by related human sciences operating with Mode Six, Mode Seven, and Mode Eight. The human sciences, like the life sciences, are far more interdisciplinary than isolated (Lund et al., 2020). Education paradigms floating free from empirical testing or scrutiny from related disciplines only amount to undisciplined speculation.

Scientific Objects, Education Objectives

Motivational and methodological commonalities are pervasive between the human sciences and most scientific fields. Their respective missions may yet be responsible for irredeemable tensions between them. Even if human sciences respect science's methods and knowledge to understand humanity, scientific theories and scientific applications may be neither humanistic nor historical. If science reduces its subjects down to objects, what happens to educational objectives?

Protests against scientific intrusions into humanistic areas try to awaken us to looming threats. Four typical contentions suffice to highlight deep tensions:

> Science has to be basically quantitative, awkward at best with the qualitative world unless registered information is rigidly categorizable.
>
> Scientific views have to conceptualize people and their activities in collective terms, reducing particular individuals and deeds to essentialized kinds.
>
> Scientific theories produce regularized formulations ready for routine application to generic objects to achieve standardized outcomes.
>
> Scientific theories postulate or presume lawful relations among natural kinds in order to explain events in deterministic and predictable ways.

On this accounting, it appears that science cannot appreciate uniqueness, difference, diversity, or self-determination. Humanistic disciplines by their nature must respect and protect those values. All the same, different disciplines have different practical means for achieving their valued ends. This is just as true for the natural sciences as the human sciences. Most scientific fields never approach the mechanistic models of Mode Nine science, while offering practical approaches to any number of human problems. As for education, it has its own practicalities as well as its principles to jointly consider. Surely there must be common practical ground, and educational research operates well there.

The practical mission of a human science, such as education in its research mode, cannot get fixated on uniqueness or diversity for its own sake, since it seeks sharable lessons and teaching practices applicable to groups of learners displaying much in common already. Finding commonalities among groupings is just as much a human affair as it is a scientific matter. The notion that science turns everything it touches into cold dead objects is entirely unfair and demonstrably untrue for most scientific fields. Let us review Dewey's insistence upon the broad meaning to "science" with his reminder in full:

> There are those who would restrict the term to mathematics or to disciplines in which exact results can be determined by rigorous methods of demonstration. Such a conception limits even the claim of physics and chemistry to be sciences, for according to it the only scientific portion of these subjects is the strictly mathematical. The position of what are ordinarily termed the biological sciences is even more dubious, while social subjects and psychology would hardly rank as sciences at all, when measured by this definition. Clearly we must take the idea of science with some latitude. We must take it with sufficient looseness to include all the subjects that are usually regarded as sciences. The important thing is to discover those traits in virtue of which various fields are called scientific. When we raise the question in this way, we are led to put emphasis upon methods of dealing with subject-matter rather than to look for uniform objective traits in subject-matter. From this point of view, science signifies, I take it, the existence of systematic methods of inquiry, which, when they are brought to bear on a range of facts, enable us to understand them better and to control them more intelligently, less haphazardly and with less routine. (Dewey, 1929/1984, pp. 3–4)

As Dewey knew well, there is no singular thing as "science" but only a multitude of scientific approaches to particular problems and inquiries.

Educational research would indeed be irresponsible for imposing some singular notion of scientific method that does not actually exist in the sciences or for seeking greater uniformity or precision than its subject matter can bear. To find a good fit between teaching and learning, the ways that a group of learners are alike supply the clues for discerning how they can learn best. Experimenting with groups to discover their shared attributes, abilities, and attainments shows no disrespect to any among them. If some individuals are too distinctive to belong to this grouping or that, then new research groupings would be the intelligent response, instead of raising old gripes against science.

Disputes between education and science can be amicably settled. Perhaps the intractable arguments over science in education erupt at the internal borders among educational policy, educational administration, and educational research. Undisciplined education permits these debates to take over the entire field's agendas. One such dispute is fueled by the view that encouraging educational research to be more scientific has the effect of endorsing the restriction of education to standardized teaching and testing. Another oft-heard view instead holds that encouraging educational research to empower teachers as co-investigators has the effect of abandoning the administration of schooling to chaotic methods and outcomes. Education must indeed deliberate about abstract educational goals, but placing the blame on empirical research is a fallacious distraction and a disservice to those most in need of education.

Conclusion

For both education and science, mind is the mission. Through its own traditions, research programs, and collaborations with other human sciences, education is a discipline displaying an unbounded potency for advancing human understanding and achievement.

(1) What is scientific and what is educational are unified at their root by exploratory discovery.
(2) Education is a humanistic discipline about culture rather than a scientific field about nature.
(3) Learners and teaching practices can be studied by the human sciences.
(4) Education's humanistic ends are aided by knowledge about the capacities of those to be educated.

Inhuman reductionism cannot be the agenda of human sciences adapting scientific methods to their missions (Kagan, 2009; Slingerland, 2008). Complaints over scientism disrupting education or distorting the discipline of education can easily be overblown and often as ideologically motivated as the alleged scientism. The label of scientism is thrown at so many different abstractions (Shook, 2015) for polemical purposes that it is becoming meaningless in academic discourse. Scientific methods and modes, by contrast, are easily discriminated. Nonideological education, as observed in previous sections, has to foster explorative, experimental, and expansive opportunities for every mind.

In conclusion, education and science are far from opposed, sharing the goal of discovery to empower humanity. Science strives for knowledge alongside education, and knowing the world is never contrary to knowing thyself. Learning prepared for ever-more learning, and applied to every art worth doing, remains free.

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