Teaching Logics through Their Philosophical Commitments: “Logical Worldviews”

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Abstract
I have developed a pedagogy and textbook for teaching logic centered on what I call “logical worldviews”. A logical worldview examines the close connection between philosophical commitments and the logical principles and method for a particular historical logical system. The class examines multiple historical logical worldviews to show how philosophical positions and logical systems have been closely intertwined, and how changes in philosophical positions have over time yielded corresponding changes in the development of logic. Such an approach has great benefits for teaching logic to undergraduates.

1 A “New” Approach to Teaching Logic to Undergraduates: Logical Worldviews

Since 2006, I have developed an approach to teaching logic to undergraduate philosophy majors that bases logic instruction in the philosophical background underpinning historic logical systems. Starting in 2013, I expanded this pedagogical approach to a general education introductory logic class, which is open to students of any major and at any stage of their college career. This curricular development has culminated in a textbook designed for an introductory logic course that can be used by teachers with minimal or no experience in the history of logic.

In the textbook I present a re-contextualization of classical formal logic as just one of many approaches to logic, each having its own philosophical commitments and unique value. I suggest that there is more to logic than is construed by only considering its contemporary formal aspects; after all, formalism in mathematics and logic is a relatively recent innovation, adopted in part because of other, non-mathematical considerations and commitments.

I hold that the history of logical thought includes a series of logics, or logical systems, each of which has non-formal philosophical commitments. I further hold that these commitments are not separate and independent add-ons to the logical system, but that the logical method and fundamental principles of the system are shaped and determined by these commitments. Though a historical logic can be considered formally and in the abstract, such a perspective yields an inaccurate account of what the logical system was intended to do by its author, of the true power of its methods of reasoning, and of the precise meaning of the logical principles employed. When the logical system is considered in conjunction with the intertwined philosophical commitments, I characterize this broader conceptualization as a “logical worldview.”

2 Using Philosophy to Better Understand a Logical System

It will be useful at this point to consider a particular example, and Aristotle is perhaps the best place to start: after all, as the first to fully develop a logical worldview, many later
logics were (as I present in the textbook) a response to rejecting one or more Aristotelian philosophical commitments. What follows is a very brief (and incomplete) characterization of some of the philosophical commitments in Aristotle’s logic.[1]

1 Theory of truth: Correspondence. Propositions are true if and only if they correspond to how the world actually is; false otherwise. Somewhat anachronistically, we might refer to propositions as being true if and only if they correspond to facts about the world. This view also includes bivalence – propositions are either true or false.[2]

2 Access to truth: Direct Realism. Human beings can directly access the world, and the properties and entities they perceive are (generally, in principle) the same as the actual properties and entities that exist in the world.[3]

3 Theory of mind: Simple Apprehension and Judgment. The human mind has a capacity to discern the true properties of things. Further, we are capable of abstracting from particular properties to universal forms shared by more than one individual entity, and recombining such forms in the imagination and in memory. Finally, we can combine previously unseen combinations of forms and judge whether or not such propositions correspond to reality.[4]

4 Metaphysics: Substances, Forms and a Hierarchical Ontology. In Aristotle’s account, the world is constituted by individual entities, or primary substances, each of which has a number of properties, or forms. Substances can be grouped together into secondary substances, or species, for which some forms are essential, others not. Species can be grouped together into a higher-order grouping, or genus, which have their own essential forms. Collectively the interconnection of species and genus through essential forms constitutes a hierarchical ontology, which is rationally discernible.[5]

In my textbook I explain how these (and other) features of Aristotle’s philosophical worldview determine the specifics of his formal logic. I’ll sketch this dependence briefly here.

First, individual substances and their forms are the fundamental perceivable elements of reality. Collectively, these are referred to as “terms”, which are the atoms of Aristotle’s logical system.

Second, propositions are assertions about the actual facts of the world. Any fact will fundamentally involve two components: an identified subject and one of its forms. Since propositions correspond to these fundamental facts, every proposition will have only two terms: a subject term (what the proposition is about), and a predicate term (what is being said of that subject).

Third, through experience, induction, abstraction, and natural talent, humans are capable of discerning some of the essential qualities of substances. This allows us to generalize beyond

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1 Here and throughout this paper, I present the philosophical views in an introductory and casual manner, to match the form in which they are presented in the textbook. Though some of these Aristotelian interpretations are contested by scholars of Aristotle, a close and well-defended history of Aristotle’s logical and philosophical positions would not be to the point. What matters for the sake of this pedagogical approach is that philosophically and historically inexperienced students see that Aristotle’s logical system is amenable to being better understood by framing it in terms of philosophical positions that Aristotle (plausibly) held.

2 See Aristotle Categories chapter 14.

3 See Aristotle de Anima, particularly Book II chapter 12 through Book III chapter 4.

4 See Aristotle On Interpretation chapter 1 and Posterior Analytics Book II chapter 19.

5 See Aristotle Categories; also Metaphysics.
particular substances to be able to quantify the scope of the assertion (all, some, one) and whether the subject and predicate are linked (affirmation) or separated (denial).

Fourth, through our capacity to discern the ontological structure of reality, we are able (in principle) to choose any two propositions and connect them by means of something in the hierarchy that links them (a middle term). The fundamental form of reasoning from one proposition (with two terms) and another (sharing one of those terms) is through a bridge proposition, sharing a “middle” term with our premise and conclusion. This is the minimum size of an argument productive of new knowledge, and thus the syllogistic form must have three propositions sharing exactly three distinct terms.

This is a rough and quick sketch of how Aristotle’s philosophical commitments determine the form of his logical method, which culminates in the syllogism. This perspective on Aristotle’s logical worldview also helps to explain many other curiosities about Aristotle’s logic that have perplexed many trying to understand his logic. I can’t get into them in detail here, but here are a few positions in Aristotle’s logic that are explained by considering his philosophical commitments.

- **Reduction to the first figure.** Rather than be satisfied with identifying valid syllogistic moods, he takes great pains to reduce them to four figure one moods. He does so because he believes that these four moods are the fundamental natural and self-evident reasoning patterns for human beings.

- **The missing fourth figure and two moods.** In inventorying valid moods, Aristotle neglects to identify two valid moods in figure one and figure four altogether. These moods do not fit the “natural” reasoning patterns determined by Aristotle’s view and are thus neglected as inappropriate forms of human reason.

- **Existential import.** Many have found that Aristotle’s inference that “All S are P” implies “Some S is P” to be logically invalid. However, given his philosophical commitments, no universal claim could ever be made without first establishing the truth of the particular, so the truth of the universal will always imply the particular.

Though this exposition of this logical worldview is seriously abridged, it should demonstrate that the form, method and logical principles of Aristotle’s logic are heavily dependent on Aristotle’s philosophical commitments. Those who wish to teach Aristotle’s logic to students can use the logical worldview in order to have Aristotle’s logic make much more sense to students, and show how his logic is closely connected to many of Aristotle’s other philosophical positions.

### 3 Using Philosophical Commitments to Explain Transitions from One Logical System to Another

I’ll briefly discuss how later logical systems can be understood as having rejected or modified some part or other of Aristotle’s logical worldview. I’m not suggesting that these later logics were the result of simply abandoning some philosophical commitment or other of Aristotle’s; rather, by rejecting one or more commitments, new opportunities for logical method are opened up, which in combination with some innovations led to new ways to do and conceive logic. I’ll briefly consider here two logical worldviews post-Aristotle.

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6 See Aristotle *Prior Analytics* Book II chapters 1-15.

7 For a good discussion of this issue see Lynn E. Rose, “Aristotle’s Syllogistic and the Fourth Figure,” *Mind* vol. 74, no. 295 (July 1965): 382-389.
Bacon’s rejection of Aristotle’s theory of mind: a motivation for natural history and modern natural sciences. In Bacon’s *New Organon*, he takes Aristotelian philosophers to task for relying too heavily on our natural capacity to understand the forms present in reality and argues that nature is far too subtle for our unaided sensory and cognitive capacities. He argues that we must develop new instruments to enhance our senses (microscopes, thermometers, etc.) and to enhance our cognitive discernment of what we are seeing by means of experiments. Since our capacity to naturally discern the forms in reality is flawed, we must develop a new logical technique, which is basically induction from a very large number of particular instances towards generalizations of increasing universality and confidence. Therefore, the syllogism, which relies on gathering information about forms and then deducing new truths is for Bacon the wrong logical method. Bacon does not reject Aristotle’s other philosophical commitments mentioned above, and to varying degrees and with some modification, the natural sciences still endorse a correspondence theory of truth, a capacity to discern forms of substances, and a hierarchical ontology.

Boole’s rejection of Aristotle’s Direct Realism and metaphysics: an effort to mathematize logic. To a great extent Newton’s mathematical approach to physics follows similar rejections as Boole, but for the sake of what will soon become clear, Boole’s contribution to logic is easier to present to students. Starting with the Early Modern philosophers in the 17th century and culminating in the modern approach to science in the 19th, the rejection of Direct Realism became fairly common. Philosophers were no longer inclined to believe that we had direct access to the substances and forms through our senses exactly as they are in reality. Because we lacked the capacity to see the world as it actually was, Boole changed the focus of logic from terms to classes in his seminal work *The Laws of Thought*. Instead of the logical atom being a term, which required discerning the true forms of individuals, he made the fundamental element the class, a collection of individuals gathered in some (perhaps unknowable, perhaps arbitrary) way. One could identify a class without having to know exactly what was required for membership. His particular brilliance was to show that the logical method of Aristotle could be encompassed within an algebra for classes. By shifting from term to class, Boole needed a new logical method, which he found in algebra. Though Boole mathematized logic, one should note that he did not abandon Aristotle’s philosophical commitments completely: he still largely conceived of reality as being metaphysically ordered in a hierarchy, and also that truth was established by correspondence. Further, he did believe that he had discovered the “laws of thought”: the actual laws by which human minds reasoned, maintaining a close link between logic and theory of mind.

I hope that these two brief sketches outline how disparate logical systems in history may appear to be radically different, but that their differences are in part due to rejecting or modifying some basic philosophical (and non-logical) positions. These transitions can show

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8 He makes this case over the course of Book I.
9 This technique is laid out in Book II.
10 See Boole *The Laws of Thought* chapter 1. As an interesting philosophical divergence into the history of computing and artificial intelligence, I often have students learn and discuss the development of logic machines in the 1870s following Boole’s logical system. These machines prompted a brief but lively debate amongst American logicians such as C. S. Peirce as to whether machines that followed the laws of thought actually were thinking. (see C. S. Peirce, “Logical Machines,” *The American Journal of Psychology*, vol. 1, no. 1 (Nov. 1887): 165-170) The view seemed generally to be in the affirmative. Eventually, however, those doing algebra of logic dropped their commitment to linking logic to laws of thinking. (see, for example, chapter 1 in Louis Couturat, *The Algebra of Logic* (Chicago: Open Court Publishing, 1914))
students that historical logics are not useless or obsolete; instead, they are evolutionary predecessors to later logics (and ultimately contemporary classical logic). These historical logics can still be valuable and useful to the contemporary student, should one embrace the philosophical commitments underlying the logical worldview.

Over the years, I have taught and analyzed a number of different historical logical systems and perspectives by means of a close examination of their philosophical commitments. In addition to those systems mentioned above, I have found that at least the following logical approaches can be analyzed in this way: Medieval faith and reason, propositional and predicate logic, mathematical physics (a la Newton), Ancient/Medieval problem of universals, nominalism, Leibniz’s logical innovations, logical fatalism, logical atomism, logicism, and the theory of relations. I anticipate many more, if not most, historical logics and logical issues would also be amenable to this pedagogical approach.

## 4 Pedagogical Benefits of Teaching Logical Worldviews

In teaching introductory formal logic to undergraduates one may have encountered the following scenario: those students who have an affinity to formal reasoning (e.g. math, computer science, and science students) take rather well to logic, but other students (e.g. humanities and social science students) struggle. This should not be too surprising, given the mathematical basis for contemporary formal logic. But what to do with those students left behind? And though the power and flexibility of formal logic is well demonstrated, especially relative to earlier approaches to logic (such as Aristotelian logic), students that are not mathematically inclined find formal logic both confusing and limiting. Such students may be capable of reasoning well, and may have a great deal of experience and success in reasoning, but often find that their previously successful reasoning practices are not well captured by the methods found in classical formal logic. One solution to this mis-fit is addressed by courses in informal logic (sometimes called “critical thinking”). And though such an approach to reasoning more closely fits the more natural, intuitive, and practical forms of reasoning of interest to many college students, it typically achieves this result by minimizing or avoiding formal reasoning altogether.

The contemporary setting of formal logic in introductory undergraduate education is a difficult, if not paradoxical one. Students not already open to formal reasoning often find formal logic not very “useful”, and many struggle to see the value or purpose of learning it. This is further compounded when formal logic is taught by philosophy departments, a discipline that otherwise frequently engages in applied reasoning in a variety of fields of contemporary relevance (science, religion, art, ethics, etc.), and in “big” questions that are quite meaningful to students in their lives (“What is the meaning of life?” “What is the best life one can live?” “What is the right thing to do?”). It is rare for a logic class to turn from the study of formal reasoning methods to connecting those to issues of current interest (“informal” or philosophical reasoning), and so students who do ultimately learn formal logic have great difficulty applying their new skills to questions of particular interest to them.

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11 By the way, in my textbook I use logical worldviews to show how contemporary propositional logic results from abandoning a commitment to a correspondence theory of truth and the resulting modification of the algebraic method of Boole’s logic. This philosophical position is partly inspired by formalism – often identified with Giuseppe Peano and many of his Italian colleagues. See Paolo Mancosu, Richard Zach, and Calixto Badesa, “The Development of Mathematical Logic from Russell to Tarski, 1900-1935” in The Development of Modern Logic, edited by Leila Haaparanta, p. 318-470. Oxford: Oxford University Press, 2009.
unless they continue on with more advanced philosophy courses.

By understanding logical systems and methods in the context of their philosophical commitments, students are exposed to the close connection between logic and philosophy. They learn why logic has the method it does, which helps them engage and understand the material more deeply than simply challenging them to master the mathematical methods of contemporary formal logic. Further, students learning logical worldviews are more capable of knitting together formal logic and “informal” or philosophical reasoning, as these approaches are explicitly linked. Finally, logical worldviews demonstrate how logic is closely connected to philosophy, and it is rather easy to introduce philosophical questions of interest to students in the midst of learning a logical system.\footnote{For example, students can explore logical fatalism (and their more philosophically interesting versions concerning free will and determinism or divine foreknowledge) by exploring the consequences of Aristotle’s commitment to a correspondence theory of truth and bivalence. Also, students can better understand Anselm’s ontological argument and Guanilo’s reply by seeing how Anselm’s position is grounded in Aristotle’s own reductio proofs, and Guanilo’s on Aristotle’s theory of mind and direct realism.}

\section{Benefits of Teaching Logical Worldviews to History of Philosophy}

Most logic textbooks, and by implication, most undergraduate logic classes teach a system of formal logic developed in the 20th century (except, in some cases, a cursory examination of syllogistic reasoning). This approach to logic has some disturbing implications for the 2,500 years of philosophical reasoning that preceded the 20th century. The considerate student (as well as many professors) may draw any or all of the following conclusions about pre-20th century logical reasoning:

1. Logic from these time periods was either wrong, incomplete, or unacceptably limited in scope and methods. After all, if such logics were suitable, why develop contemporary formal logic that encompasses and surpasses such logics?
2. By extension from this first point, philosophical reasoning based on earlier logics could similarly be considered to be flawed, obsolete, or otherwise useless. Some schools of philosophical thought have explicitly embraced this perspective (e.g. the Logical Positivists); today, this perspective is often implicit in attitudes about historical philosophy from a wide variety of fields (every so often one will make such an assertion explicitly, as Stephen Hawking recently did).\footnote{See Stephen Hawking and Leonard Mlodinow, \textit{The Grand Design} (New York: Bantam Books, 2010) chapter 1: “Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge.”}
3. Many contemporary philosophers (students and professors) educated in contemporary formal logic enough to use it to parse examples of natural reasoning will use it to parse examples of philosophical reasoning that pre-dates mathematical logic. This is anachronistic to say the least, and results in a misleading conception of the actual reasoning made by these historic figures. Further, it is likely to construe historical philosophy in a bad light, since it makes it appear that these historical figures engaged regularly in invalid reasoning for most of the intellectual history of Western thought.

For some, these considerations are not of much concern: many do, in fact, believe that history is rife with examples of bad reasoning, just as up to the scientific revolution, history was plagued with examples of bad science. This perspective is reinforced by the (mostly
legitimate) observation that some of history’s most highly regarded philosophical reasoners seem to have made grave errors in their knowledge claims (Aristotle is a significant target here).

In math and science an ahistorical perspective may be appropriate: after all, most science and math textbooks teach the completed current state of knowledge, not the long and difficult (and in many cases wrong) path that led us here. Outside of these fields, however, the value of accurately understanding past perspectives is more apparent: many areas of study in the humanities and social sciences to this day engage well-reasoned theories dating back to Ancient Greece.

Setting concerns about history of philosophy aside, a large number of people presently endorse Aristotle’s philosophical commitments enumerated above and teachers would likely find that most of those people would have little problem with syllogistic reasoning. In contrast, I expect that most teachers of logic find that many students find much of contemporary formal logic counter-intuitive and alien to how they reason. In contrast, logical worldviews can help the logic teacher show that in certain philosophical contexts, particular historic logics may be the best approach; but that should those philosophical commitments be rejected or disproved in other reasoning contexts, different logics are called for. A student’s intuitive reasoning can be embraced rather than replaced, which would certainly seem to be a desirable outcome for a logic class.

6 Benefits for the Teacher of Logic

I’d like to finish up by discussing a few benefits for the logic teacher who adopts this approach. I’ve designed the textbook to contain a number of different modules, each examining a different logical worldview. As I complete more modules, the textbook will fill up with a fair number of unique instances of logical systems spanning the last 2,500 years. Each module contains several key components: (1) an inventory of the philosophical commitments of the logical system; (2) a trace of the connection between the philosophical commitments and the development and form of the logical method and principles employed; (3) an introduction and discussion of some interesting philosophical issues that arise under this worldview.

Each module is designed to be teachable by those with only a minimal expertise in the history of philosophy. The characterization of a logical worldview does depend on a historical interpretation of the philosophy and logic under study, but a background in historical scholarship is not required in order to understand or teach the main components of each module. Instead, anyone with a good background in philosophy should be able to comprehend and easily teach the first and third components (inventory of philosophical commitments, and linkage to philosophical issues). The second component of each module (tracing the connection between the philosophy and the logic) is more subtle and complex, but should be within reach for anyone experienced in teaching logic.

Modules are designed to be able to be taught independently, although many are closely related to others. This allows the teacher to pick and choose a path through the history of logic, and thereby emphasize the impact of different philosophical views on the development of logic and/or our understanding of certain logical concepts and methods. For example, in a logic class that culminates in teaching propositional and predicate logic, one might

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14 As mentioned earlier, this involves presenting a simplistic interpretation which historians of philosophy might find unsupported by sufficient research and scholarship. However, most textbooks are likely subject to the same complaint, and thus this publication genre permits, if not requires, such oversimplification.
start with Aristotle and then pick modules that progressively show how logic became more mathematical and abstract (by for instance, selecting logical worldviews of Leibniz, Boole and Russell as transitional modules). On the other hand, a course interested in the logic of the scientific method might feature the logical worldviews of Aristotle, Medieval faith and reason, Bacon, and Newton.

In conclusion, I have found this approach to be of great benefit to students and to myself by expanding teaching of logic beyond the boundaries of formal methods and systems. Students seem to derive a deeper understanding of logic by seeing how it connects with other philosophical positions. Further, this approach helps make logic more comprehensible to the broad pool of students who are either disinclined or not well suited towards the strictly formal, mathematical approaches to teaching logic so commonly taught today.