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Isidoro Talavera
Franklin University, isidoro.talavera@franklin.edu

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The Problem of Teaching the Science of Climate Change:

A Call for Critical Thinking in Teacher Education and Professional Development

Isidoro Talavera
Franklin University, USA

ABSTRACT

This article discusses how to teach the science of climate change as a call for introducing critical thinking in science teacher education programs and professional development. It can be argued that to get a science student to develop his/her critical thinking skills to think outside the box, teachers must work to overcome the student's and their own dogmatic beliefs, hardened biases, and motivated and/or distorted reasoning. The article shows how teacher education programs and professional development providers should change their methods and strategies by providing a framework to overcome the key elements of the problem of teaching the science of climate change, and by providing some high-quality resources to teach this topic with practical ideas made available for teachers at all levels.

KEYWORDS

Dogmatic Beliefs, Hardened Biases, Motivated And/Or Distorted Reasoning, Critical Thinking Skills, Scientific Knowledge, Cognitive Dissonance, Logical Arguments, Science Student, Science Teacher

INTRODUCTION

This treatise addresses how to teach the science of climate change (previously presented as a conference paper; see Talavera, 2023). It calls for introducing critical thinking in science teacher education programs and professional development. It argues that to get a science student to develop critical thinking skills to think outside the box, teachers must work to overcome the students' and their own dogmatic beliefs, hardened biases, and motivated and distorted reasoning.

Accordingly, teacher education programs and professional development providers should change their methods and strategies by providing a framework to overcome the key elements of the problem of teaching the science of climate change by discussing the need to teach the controversial science of climate change, the inability of teachers to effectively engage science students, how to address the controversial issue of climate change, and the teaching strategy of critical thinking. The key elements for teaching the controversial issue of climate change are (a) the intersecting problems that war against the scientific case for urgent action to limit climate change; (b) an example that provides the case for the context in which teachers may actually introduce critical thinking; (c) the critical questions that must be applied to claims about climate change; and (d) the specifics of our teaching strategy by highlighting the critical thinking in science that analyzes and evaluates arguments, and engages in a form of methodological skepticism that systematically and continuously asks critical questions. The

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detailed appendix and a bibliography, present some high-quality resources to teach this topic with practical ideas made available for teachers at all levels. In short, by actively comparing the students' initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions, the framework and related resources will help educators deal directly and systematically with the misconceptions and resistance to the science of climate change.

FRAMEWORK FOR HOW TO TEACH THE SCIENCE OF CLIMATE CHANGE

The Need to Teach the Controversial Science of Climate Change

There is a stark fissure between scientists and citizens about whether climate change exists and whether it is due primarily to the human use of fossil fuels (Funk & Rainie, 2015). Moreover, there is also public resistance to thinking critically about this issue, supported by hardened beliefs, motivated reasoning, fallacious thinking, and misinformation. To deal with such challenges, this treatise adopts a common core understanding of critical thinking that takes an argument apart using analysis and evaluates whether any resulting conclusion follows accurately from the evidence (see Crazypills, 2009, and QualiaSoup, 2009).

Accordingly, there is a need to deal with publicly popular resistance to—and misconceptions and distortions about—the issue of climate change (Union of Concerned Scientists, 2018). This demands that we promote and defend the integrity of science education in the face of the climate change controversy and help teachers gain the confidence and support they need to teach the science of climate change effectively against the tide of cultural, political, and religious ideological interference. Notably, the National Center for Science Education (https://ncse.com) defends the integrity of science education against ideological interference. It works with teachers, parents, scientists, and concerned citizens at the local, state, and national levels to ensure that topics like climate change are taught accurately, honestly, and confidently.

These changes in our science teacher education programs are crucial for our survival as a species because society and the relationships among individuals within a society influence how we make choices and how policy discussions might (or might not) improve how we think about climate change. Accordingly, only when the currently low scientific literacy of the American population rises to the level of accurate and sympathetic understanding of science will the appeal of nonscience, pseudoscience, and just plain bad science diminish sufficiently to disable the quackeries that today prey upon people. However, at least in America and probably in the United Kingdom as well, no improvement can be expected until there are major changes in the way schoolteachers are trained to teach science (Forrest & Gross, 2005).

The Inability of Teachers to Effectively Engage Science Students

A critical concern having serious social policy implications is the distrust or denial of the science of climate change. Some people are undecided about, or simply avoid facing the consequences of, climate change, but others deny climate change exists altogether or that it is due primarily to the human use of fossil fuels. This problem of public resistance to climate change is compounded by the reality that science faculty have often avoided teaching controversial issues in science classes, since much of the students' resistance is framed in cultural, political, and religious terms, and science teachers are usually reluctant to address such ideas in class (Nelson, 2008).

Moreover, many science instructors are simply not able to master and teach critical thinking well or are not entirely effective in passing on scientific knowledge because they are themselves suffering from cognitive dissonance (Eve & Dunn, 1990; Impey et al., 2012; Talavera, 2016). Unfortunately, learning to teach critical thinking (and assessing an instructor's success teaching it) is not quite as straightforward as the outcome-based minded may think—pragmatically linking, for example, critical thinking with Bloom's Taxonomy. No matter how practical it sounds, this is an example of picking the wrong tool for the job: this approach is flawed. Philosopher Richard W. Paul (2012, 519-526) argued that while Bloom's distinctions themselves are important, the common understanding of their link to critical thinking is largely misconceived (see Talavera, 2006).

Eve and Dunn (1990) noted the importance of learning the philosophy and methodology of science:

A review of recent reports on the state of education in the U.S. indicates that there is much concern today over whether science teachers have received adequate instruction in the philosophy and methodology of science. Because this type of training is a critical tool for distinguishing between bogus scientific beliefs and valid scientific findings, it is likely that some teachers may not have the educational foundation necessary for recognizing pseudoscientific claims. . .. [So, for example,] while there are many qualified and even exemplary biology teachers, the number of those who [do] not exhibit adequate scientific reasoning skills is significant enough to justify alarm. . .. [Moreover,] a significant proportion of high school life science and biology teachers hold many beliefs which are at odds with mainstream science. . .. [Thus,] many teachers are not only failing to impart basic information on the scientific method to their students but are also likely to be misinforming students because of their own beliefs in pseudoscience. (The American Biology Teacher, 52(1), 10–21)

How to Address the Controversial Issue of Climate Change

One way to deal with the foregoing problem and help increase the public understanding and valuation of science is to engage our students philosophically with a call for critical thinking—principally, as each pressing scientific issue has played out in the public sphere. For instance, a classroom discussion about the problem of climate change can logically begin by questioning the much-reported evidence supporting an overwhelming scientific consensus maintaining that climate change exists and is due primarily to the human use of fossil fuels. Most in the scientific community maintain that global warming is no longer a debate (Consensus Project, n.d.; Cook et al., 2013). Nevertheless, a wider philosophical debate that brings divergent views to the table can be encouraged in the science classroom so that intersecting arguments that war against the scientific case for urgent action to limit climate change may be analyzed and evaluated. The following sections will discuss how to engage in such a wider philosophical debate using critical thinking.

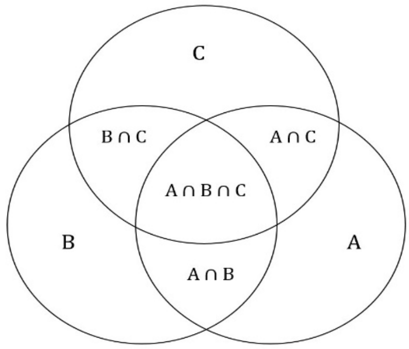
The Teaching Strategy of Critical Thinking

As a public-facing form of philosophy, a teaching strategy requires a critical thinking approach (Talavera, 2016) that, when applied to claims about climate change, can help the educator present a more robust picture of this life-threatening issue and deal directly and systematically with student misconceptions and resistance to modern climate science. For instance, misconceptions and resistance need to be confronted in biology and life science courses (see Nelson, 2008). By highlighting the critical thinking in science that analyzes and evaluates arguments and engages in a form of methodological skepticism that systematically and continuously asks critical questions, the educator can help students actively compare their initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions.

Teaching About the Intersecting Problems That Resist the Scientific Case for Urgent Action to Limit Climate Change

Climate change effects may be experienced in our lifetime in the form of ecological impacts (e.g., the coral bleaching and acidification of the oceans projected to kill one-third of all marine life, affecting biodiversity), agricultural impacts (e.g., the loss of arable land due to flooding), economic impacts (e.g., the loss of income from arable land crops due to flooding), and impacts on society (e.g., the heavy migration of people displaced by flooding). Dealing effectively with such possible

Figure 1. Overlapping Sets A, B, and C



dire effects demands that we look critically into the specific problems that war against the scientific case for urgent action to limit climate change.

For analysis and evaluation (i.e., critical thinking), consider the following conceptual map constructed to reveal the logical space of all the possible options of the debate, showing the overall complexity of the challenge as grasped by three overlapping sets. In Figure 1, Circle A represents the problem of accepting consensus, Circle B represents the problem of separating skepticism from denial, and Circle C represents the problem of ignoring impact. As we look deeper into the following options (i.e., sets and subsets) and their respective logical implications to present a more comprehensive, consistent, and unified front in our line of reasoning and call for action, we will need to focus on the different options below—coming from different supporters of a pre-emptive anti-scientific stance framed in cultural, political, or religious terms.

The problem of accepting consensus (Circle A) has to do with not accepting scientific consensus—a knowledge-based consensus among most scientists based on converging evidence and rigorous analysis and evaluation, which is backed up with scrutinized peer-reviewed research (that must pass the test of time after publication). For instance, some do not accept the scientific consensus that there is a link between carbon dioxide and global temperature, that more carbon dioxide will make a difference, or that we can reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years. This may be because resistance to climate change is usually based on pseudoscientific or non-scientific beliefs or on some point of view suffering from cognitive dissonance (Eve & Dunn, 1990; Impey et al., 2012; Talavera, 2016).

The problem of separating skepticism from denial (Circle B) has to do with mistaking denial for skepticism. So, for example, one may simply deny a belief (doubted on the merit of some strong or fixed view held in advance) and announce to the world that this is just skepticism. One may claim to be adopting a skeptical stance by simply denying the belief that humans are causing global warming because one believes God controls the climate and warming is evidence that the world will be ending soon and that we do not need to worry about global warming in light of the approaching apocalypse (adapted from Roser-Renouf et al., 2016). So, why bother polishing the brass on a sinking ship? Nevertheless, this denial is just a part of a motivated reasoning process that gathers only evidence that supports the advanced view (cherry-picking and ignoring the rest). Consequently, hard evidence, as required by true skepticism, is never (or can never be) provided as part of the critical thinking process seeking possible errors to correct.

The problem of ignoring impact (Circle C; National Research Council, 2012) concerns closing one's eyes to the effects of climate change in one's lifetime because of deep-rooted myths (*Skeptical Science*, 2017), such as the following.

1. The negative effects of climate change are distant in space (e.g., "Only about polar bears and penguins living at opposite ends of the world, not us") and in time (e.g., "Only about future generations, not us"; UQx Denial101x Making Sense of Climate Science Denial, 2015);
2. We do not need to worry, for example: "Who says climate change is such a bad thing?", "We are heading toward an ice age, so why worry about warming?", and "There is no link between warming and extreme weather" (Darling & Sisterson, 2014);
3. Climate change is not happening, for example: "It feels pretty cold. Where is the global warming?", "Glaciers are growing and Antarctica is gaining ice, so the planet is not getting warmer", and "The climate is too complex to model or predict" (Darling & Sisterson, 2014);
4. It is not our fault, for example: "It is just a natural cycle or variation", "The heat energy is coming from the sun", and "Volcanic eruptions release greater amounts of carbon dioxide than humans do" (Darling & Sisterson, 2014) and,
5. There is nothing we can do about it, for example: "Carbon taxes or cap-and-trade systems will destroy the economy, kill jobs, and hurt the poor", "Renewable energy is too expensive or too variable", and "Global carbon dioxide emissions from burning fossil fuels have already exceeded the limits that some scientists believe could prevent catastrophic climate change" (Darling & Sisterson, 2014).

Example: Teaching Critical Thinking Applied to the Claims About Climate Change

Given the foregoing framework of the problems that feed into the war against the scientific case for urgent action to limit climate change, let us turn to an example that provides the case for the context in which teachers may introduce critical thinking. Consider, for instance, a lesson plan about climate change in a science class that introduces the claim for discussion: Humans today are emitting prodigious quantities of CO_2 at a rate faster than even the most destructive climate changes in Earth's prehistoric past (*Skeptical Science*, 2017). Let us begin, for instance, by setting up what is at stake by framing the issue in terms of a cogent inductive argument for the conclusion that human-made increased CO_2 does contribute to climate change.

1. Oceans absorb 90% of Earth's heat.
2. Approximately 70% of solar energy that hits Earth is absorbed and re-emitted (some of it trapped by greenhouse gases).
3. Human-made CO_2 levels have increased greenhouse gases.
4. White glaciers and ice sheets reflect the sunlight.
5. Without sea ice, the dark open ocean absorbs sunlight and heats up, raising global temperatures, which in turn causes glaciers and ice sheets on land to melt further.
6. Melting sea ice increases heat absorbed by oceans, which causes a feed-forward cycle.
7. Thus, human made increased CO_2 does contribute to climate change.

To be sure, we can see that the problem of teaching the science of climate change, in this case, has as a source people who distrust or deny Premise 3 that human-made CO_2 levels have increased greenhouse gases. However, there is a 97% consensus among climate scientists that the earth is getting warmer and sea levels are rising, and it is primarily because of humans releasing great quantities of carbon dioxide into the atmosphere (Consensus Project, n.d.; Cook et al., 2013; Be Smart, 2014). Since the Industrial Revolution, humans have added 2,000 gigatons of CO_2 to the atmosphere, and 40% has stayed there (Le Quéré et al., 2014). Because of this extra trapped greenhouse gas (coming from burning fossil fuels; U.S. Department of Commerce, n.d.), carbon sinks and carbon sources are out of balance (ClientEarth Communications, 2020). Greenhouse gases and aerosols affect climate by altering incoming solar radiation and outgoing infrared (i.e., thermal) radiation that are part of Earth's energy balance (Intergovernmental Panel on Climate Change, 2007a). So, just as a car with its windows rolled up on a hot summer's day does not allow for venting and keeps getting warmer and warmer, the earth is getting warmer and warmer. However, the whole earth does not get hotter evenly all over. Some parts of the earth will experience a huge increase in temperatures; others are going to see the exact opposite take place (Strange Mysteries, 2016).

Because of this extra rise in temperature, mountain glaciers, and ice sheets on land are melting. In turn, the melting ice on land contributes to sea level rise. Moreover, since white glaciers and ice sheets reflect sunlight, without ice to reflect excess heat into space, the oceans absorb sunlight and heat up, further raising global temperatures. In addition, because the oceans absorb sunlight and heat up (causing a feed-forward cycle; Pistone et al., 2014), sea levels further rise due to the thermal expansion of water (Intergovernmental Panel on Climate Change, 2007b). Such consequences can no longer be brushed aside or avoided. As Yale Climate Connections noted,

> *Melting sea ice does contribute to climate change. That's because white sea ice reflects the sun. So when it melts, the dark open ocean now absorbs sunlight and heats up, raising global temperatures, which in turn cause glaciers and ice sheets on land to melt further. Globally, sea levels have risen four to eight inches since the last century and will continue to rise as the ice melts, putting coastal communities worldwide at risk. (Appell, 2014)*

Nevertheless, we need not stop there. The science educator can spice up the class discussion for the sake of critical thinking and look at the popular claim that we cannot today reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years. How do we even know how warm or cold it was in the past? Since humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, how can scientists today know about the claimed destructive climate changes in Earth's prehistoric past? Moreover, given that humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, the science educator can go on to note that this may be why (increasingly) most people are coming to believe that they should distrust or deny the science of climate change.

To sum up, a great opportunity for a wider philosophical debate becomes available as the class debates whether these claims are based on the problem of accepting consensus, separating skepticism from denial, or ignoring impact. This brings divergent views to the table so that intersecting arguments that war against the scientific case for urgent action to limit climate change may be analyzed and evaluated. Accordingly, critical thinking (Talavera, 2016) may be applied to the opposing claims to help the educator present a more robust picture of this life-threatening issue and deal directly and systematically with the misconceptions and resistance to modern climate science (see Nelson, 2008).

Critical Questions Applied to Claims About Climate Change

This section addresses the specifics of our teaching strategy by highlighting the critical thinking in science that analyzes and evaluates arguments and engages in a form of methodological skepticism that systematically and continuously asks critical questions. Here, I have significantly modified and fleshed out Battersby's four basic questions: "What is being claimed?", "How good is the evidence?", "What other information is relevant?", and "Are relevant fallacies avoided?" (Battersby, 2010). This approach to critical thinking and the following application are adapted from Talavera (2016).

Belief

For those engaged in acquiring scientific knowledge, there must be the realization that our beliefs and opinions do not always correspond with reality (see TheBroadRoadcom, 2013). In this light, experimental studies must be set up as a way to critically know reality on its own terms. Accordingly, each hypothesis can be tested for truth by means of experimentation (enter empiricism) but also justified with good arguments for believing it (enter rationalism). This helps to paint an objective and logically consistent picture of reality. So, an important question to always ask: What is the belief (or the claim, conclusion, or hypothesis)? For instance, a belief under consideration in the foregoing section is the statement: We cannot reliably determine today the past climate carbon dioxide levels dating back hundreds of thousands of years.

Skepticism

Are there reasons to doubt the belief? The problem here is that for some in the general public, paleoclimatology and geology, as historical sciences, are typically not considered to be reliable sources of knowledge that can be regarded as more suitable than others (e.g., chemistry or physics)—as the most appropriate point of departure for scientific inquiry or confirmation. This is because humans were not there in the ancient and prehistoric past to carry out experiments to confirm or falsify the science.

Historical sciences like cosmology, geology, and evolutionary biology do not fit the naïve view of scientists proposing scientific theories and then carrying out experiments to confirm or falsify them. Experiments are impossible and empirical data is hard to obtain and fragmentary. However, this does not mean that these fields are not scientific, and that their theories do not need to conform to the definition of scientific theories. It does mean that predictions become retrodictions and that a long time may pass between the proposal of a theory and the availability of data to check its retrodictions. (Ben-Ari, 2005, 197)

Accordingly, we may doubt the entrenched belief (as it has played out in the public sphere) that we cannot today reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years because one is appealing to the naïve view that scientists must all do the same things to do science. So, for instance, one may be assuming that climatologists (like all other legitimate scientists) must propose scientific theories (that can only predict effects in the future) and then carry out experiments in the present (based on empirical data obtainable in the present) to confirm or falsify them. Nevertheless, "not all scientists do the same kinds of things—some experiment, others don't, some do field observations, others develop theories. Compare what chemists, theoretical physicists, zoologists, and paleontologists do" (Paul, 2012, 612). Therefore, although it is true that humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, scientists can look backward for indirect evidence so that "predictions become retrodictions and that a long time may pass between the proposal of a theory and the availability of data to check its retrodictions" (Ben-Ari, 2005, 197). For further discussion of this topic, see TEDx Talks (2012).

Critical Thinking (Analysis Plus Evaluation)

Analysis

What is the argument for the belief? We can formulate the argument as follows.

1. If humans were not present in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, then we cannot reliably determine today the past climate carbon dioxide levels dating back hundreds of thousands of years.
2. Humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels.
3. Thus, we cannot today reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years.

What is the conclusion (or what is being claimed)? We cannot reliably determine today the past climate carbon dioxide levels dating back hundreds of thousands of years.

What are the premises, and what is the evidence?

1. If humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, then we cannot today reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years.
2. Humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels.

Are the premises true? Premise 2 is true; Premise 1 is false (but why?).

Evaluation

How good is the argument? If we let P be "Humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels", and let Q be "We cannot today reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years", we can see that this is a valid deductive argument with the logical form called *modus ponens*.

1. If P, then Q.
2. P.
3. Thus, Q.

However, although the argument has a valid deductive form, it is not sound because Premise 1 is false.

How good is the conclusion (or how good is the claim)? Although the conclusion logically follows from the premises (i.e., the claim logically follows from the evidence), the claim is false.

How good are the premises? (How good is the evidence?) Premise 2 is true (Humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels). However, Premise 1 is false because the consequent Q of the conditional statement "If P, then Q" is false, given that the antecedent P is true. Premise 1 contradicts scientific climate change research or evidence.

Does the argument meet the burden of proof? The argument is not consistent with the direction of climate change research or evidence. Moreover, the argument does not deal effectively with opposing evidence or arguments. Therefore, as it stands, it is not strong enough to counter this research or evidence. For instance, as the Earth Observatory (2010) noted,

We know about past climates because of evidence left in tree rings, layers of ice in glaciers, ocean sediments, coral reefs, and layers of sedimentary rocks. For example, bubbles of air in glacial ice trap tiny samples of Earth's atmosphere, giving scientists a history of greenhouse gases that stretches back more than 800,000 years. The chemical make-up of the ice provides clues to the average global temperature.

Accordingly, we can argue for the claim that scientists can reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years as follows.

1. Tree rings provide reliable evidence about past climates.
2. Layers of ice in glaciers provide reliable evidence about past climates.
3. Ocean sediments provide reliable evidence about past climates.
4. Coral reefs provide reliable evidence about past climates.
5. Layers of sedimentary rocks provide evidence about past climates.
6. Ancient rodent waste can give scientists an insight into how climate changed over time.
7. Ice cores of ancient ice can reliably tell us about past climates.
8. Thus, scientists have access to reliable knowledge about past climates.

9. Therefore, scientists can reliably determine past climate carbon dioxide levels dating back hundreds of thousands of years.

It is important to note that each premise above can invoke its own sub-argument to bolster the evidence it provides. For instance, Premise 2 can invoke its own argument to support the evidence that layers of ice in glaciers provide reliable evidence about past climates. Consider, for example, the following sub-argument.

1. Bubbles of air in glacial ice trap tiny samples of Earth's atmosphere, giving scientists a history of greenhouse gases that stretches back more than 800,000 years.
2. The chemical makeup of the ice provides clues to the average global temperature.
3. Thus, layers of ice in glaciers provide reliable evidence about past climates.

Is relevant information missing? Our original *modus ponens* argument ignores or dismisses the relevant context or background information about how scientists determine past climate (see Appendix).

Are relevant fallacies avoided? Given that humans were not there in the ancient past to carry out experiments to confirm or falsify climate carbon dioxide levels, one may go on to note that this is why, increasingly, most people are coming to believe that they should distrust or deny the science of climate change. Nevertheless, such an argument amounts to appealing to a growing segment of the population that believes it is popular to deny climate change. This popularity is used as the reason to establish a case against climate change science. This is called the *bandwagon fallacy* (Hansen, 2023). Such an argument is fallacious because an appeal to the meager fact that an idea is fashionable (e.g., on the basis of peer pressure, convenience, or even groupthink) as evidence does not make the idea true. Therefore, for example, one may be taken to be arguing that:

1. Increasingly, most people are coming to believe that the science of climate change should be distrusted or denied.
2. Therefore, the science of climate change should be distrusted or denied.

However, such an argument is fallacious because popularity (presented as evidence) does not guarantee the validity of an argument. So, although the premise of this argument is true, the conclusion is false. Accordingly, the invalid argument form for this line of reasoning can be displayed as the following (let X be the statement).

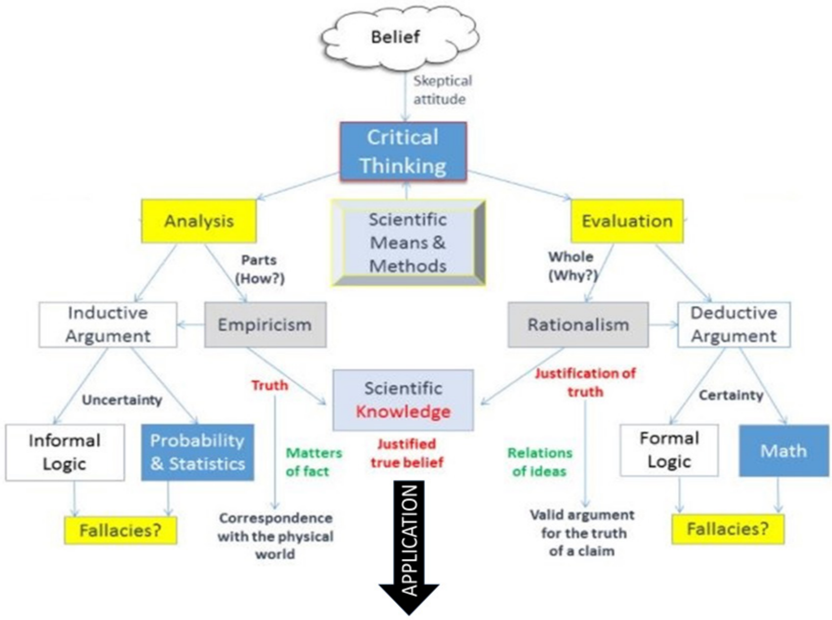
1. Increasingly, the majority of people are coming to believe X.
2. Therefore, X.

The invalidity of this argument is clearly discernable when we let X be statements like "Santa Claus exists", "Slavery is good", and "The earth is flat". In sum, given the foregoing, the educator can help students actively compare their initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions to deal directly and systematically with the misconceptions and resistance to the science of climate change.

CONCLUSION

This treatise presents a framework to overcome the key elements of the problem of teaching the science of climate change and provides high-quality resources to teach this topic with practical ideas made available for teachers at all levels. It shows how teacher education programs and professional

Figure 2. Conceptual Map



development providers should change their methods and strategies to help science students overcome dogmatic beliefs, hardened biases, and motivated or distorted reasoning.

However, the problem does not end with our students. A controversial topic that continues to be a current and contemporary issue in education and teacher preparation is that some science teachers are failing their pupils by not challenging claims for or against climate change when they come up during lessons on climate science. This is because many science instructors are simply not able to master and teach critical thinking well or are not entirely effective in passing on scientific knowledge because they are themselves suffering from cognitive dissonance. Accordingly, examining the problem of teaching the science of climate change and a call for critical thinking as it has played out in the public sphere reveals that science educators can engage students philosophically with a methodological skepticism that incorporates critical thinking.

As generalized in a conceptual map in Figure 2, this approach can be applied to many controversial and pressing scientific issues to help the science educator present a more robust picture of such life-threatening problems and deal directly and systematically with student misconceptions and resistance to modern science. This is one way to help increase public understanding and the valuation of science.

However, teaching critical thinking is like throwing high-level cognitive bricks at a glass window (our students). The glass window has the tendency to break—just like our students who have the inborn critical thinking skills waiting to be revealed. However, this latent property is not revealed until the window is hit with the sometimes overly heavy-handed and, at points, offensive brick. To teach critical thinking effectively (Talavera, 2016), then, we need to be disturbers of the peace. This means that to help our students to develop critical thinking skills and think outside the box, we must work to overcome dogmatic beliefs, hardened biases, and motivated and distorted reasoning (see MMM Global School, 2015). This can be achieved by highlighting the critical thinking in science that analyzes and evaluates arguments and engages in a form of methodological skepticism that systematically and continuously asks critical questions. In short, by engaging in a wider philosophical debate that brings divergent views to the table via critical thinking, both the science educator and students can actively compare their initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions. Therefore, teaching climate science as critical thinking is a genuine educational benefit. This approach may offset one's pre-emptive anti-scientific stance framed in cultural, political, or religious terms (Talavera, 2016).

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CORRESPONDING AUTHOR

Correspondence should be addressed to Isidoro Talavera (U. S. isidoro.talavera@franklin.edu)

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APPENDIX: RESOURCES FOR THE SCIENCE CLASS

The following articles and reports address how scientists determine past climate.

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Dr. Isidoro Talavera is a Philosophy Professor and Lead Faculty at Franklin University (College of Arts and Sciences, Ohio, USA). The focus of his philosophical research is the confluence of applied epistemology, logic, critical thinking, and the philosophy of natural and/or social sciences—emphasizing a call for public ethical and/or critical rational engagement for the survival and flourishing of humanity. Examples of this are his two seminal works published in 2022: (1) The impossibility of a Democratic society: A call for critical thinking in a time of crisis. In L. Harper (Ed.), The crisis of American democracy: Essays on a failing institution. Vernon Press; and, (2) Some problems in advancing academic inclusion: A call for critical thinking. In V. Wang (Ed.), Handbook of Research on Educational Leadership and Research Methodology. IGI Global. Dr. Talavera has degrees in Mathematics (M.S.E.) and Philosophy (M.A., M.A., and Ph.D.). He earned his doctorate from Vanderbilt University with his thesis: Time and the Nature and Possibility of Knowledge.