Fostering and Assessing Critical Thinking in the Geology Classroom

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Foundation of Development of Critical Thinking in Undergraduate Learning: The Perry Scheme

After Perry (1970)

INTELLECTUAL DEVELOPMENT

DUALISM

Positions 1 & 2

Characteristics: In early dualism (Position 1) there is an unexamined belief in Absolutes and Authority. In Position 2, students recognize uncertainty but view it as illegitimate.

View of Student Role: Receive knowledge and demonstrate having learned right answers.

View of Instructor Role: Instructor is a source of knowledge who can be counted on to know facts. Good Instructor = Knower of Truth.

View of Peers: Peers are not a legitimate source of learning.

Areas of Student Concern: If evaluation is not clear-cut or if teacher is ambiguous, uncertain or fuzzy.

MULTIPLICITY

Position 3: Early Multiplicity

Characteristics: Recognition of legitimate uncertainty but trust in Authority remains (Authority may want us to figure out the right answer for ourselves, or authority may not know the right answer yet, but the idea of objective truth remains).

View of Student Role: Role is to figure out how to do the process called for by Teacher/Authority.

View of Instructor Role: Knows the "right way" to find knowledge. Model of process.

View of Peers: More legitimate, especially in discussion, but final truth is still given only by Teacher/Authority.

Areas of Student Concern: Fairness in evaluation, concern that uncertainty may be complex and widespread.

Position 4: Late Multiplicity

Characteristics: If authorities differ, everyone's opinion is equally legitimate.

View of Student Role: Learn to think for oneself and justify arguments.

View of Instructor Role: Model of good methods of scholarship; however instructors can be largely ignored.

View of Peers: Peer's ideas are as good (or bad) as anyone else's.

Areas of Student Concern: Evaluation should be based on independent thought. Can "give instructors what they want" regardless of what you think.

RELATIVISM

Position 5: Early Relativism

Characteristics: All knowledge is contextual and no absolute truth exists. Arguments can be better or worse based on the application of explicit criteria established by those with expertise.

View of Student Role: Use intellect to apply criteria for evaluation.

View of Instructor Role: Bearer of expertise.

View of Peers: Legitimate learning sources if they correctly apply criteria.

Areas of Student Concern: Can see that there is a requirement of commitment or choice to equally good alternatives.

Perry's positions 6-9 explore more sophisticated commitments in relativism and are not outlined here.

Fostering and Assessing a Major Transition (from Perry's Position 4 to Position 5) in a Geology Classroom Using the Example of Global Warming.

This transition requires that students learn the fundamental criteria scientists use to distinguish "better" arguments from "worse" arguments. In short, this transition requires that students learn to think critically in the ways that scientists think critically.

Step 1: Set up two alternatives to compare:

1) Global Warming is a result of anthropogenic forcing.

2) Global Warming is a result of natural climate variation or other factors and the contribution of humans to this is minimal.

Step 2: Introduce criteria for evaluation of alternatives

a) Use data from FAIR TESTS for comparison: a fair test will be, most importantly, unbiased and uses different kinds of evidence from the kinds of evidence used to initially postulate the alternatives.

b) Determine whether alternatives are confirmed by multiple, independent fair tests.

Examples: Isotopic signatures show that the increase of CO_2 in the atmosphere is due to burning of fossil fuels and not from natural sources in the terrestrial biosphere.

c) Examine whether initially conflicting data can be shown to agree

Example: Average global temperatures, which have increased since the 1980s decreased in the early 1990s. However, the 1991 eruption of Mt. Pinatubo sent volcanic ash into the atmosphere, partially reflecting the sun's radiative heat and sending cooling aerosols into the troposphere, with a 1-3 year recovery period.

d) Examine whether there are conflicting lines of scientific evidence

Example: Isotopic data and data on types of marine organisms in ocean sediments plus records of glacier activity (in addition to other types of evidence) indicate that climate flux has been significant even before human influence.

e) Check to see if supporting evidence is particularly strong

Example: Data on air temperature can be variable; however, temperature of permafrost, which is more robust and less variable, in Alaska has steadily risen since the 1980s.

f) Examine whether alternatives are conceptually defective (untestable or ad hoc).

Example: No one can be sure that any climate changes have a human influence because climate models are still developing in their sophistication so we have to wait for more data to be sure.

g) Check to see whether the overall weight of evidence greatly favors one alternative over another.

Example: Although there is legitimate debate on the effects and timing of global warming (albedo effect, release of methane due to permafrost thaw, widespread drought, sea level rise, thermohaline circulation); overwhelming evidence for a human contribution (isotope signatures of fossil fuels in the atmosphere, accompanied by deforestation, ice cores in Antartica and Greenland show spikes in CO_2 content in the atmosphere at the time of the Industrial Revolution)

To work on the transition into commitment (Positions 6 and higher), combine ANALYSES (criteria above) with VALUES:

Historical and social contexts: Global warming currently directly affects only a small portion of the population (mostly in the Arctic regions) with minimal impacts on major first-world societies. However, we have a growing understanding that many major past civilizations (Mayans, Egyptians, Anasazi, among others) were destroyed at least in part due to environmental effects from warming climates and deforestation, even without major anthropogenic input.

Approximations: Acceptance of scientific evidence of warming using oxygen isotopes, for example, requires unstated geochemical criteria (assumptions of equilibrium, etc…), at what level do you need to explain evidence for general comprehension?

Inevitable tradeoffs: If fossil fuels increase greenhouse gases which lead to global warming, decrease personal fossil fuel consumption and plant more trees, but still drive cars.

Values (which groups' interest does an analysis serve and ignore?): Oil companies have a different interest in the outcome of the contribution of fossil fuels to global warming than scientists do! Or an economist might say that it is cheaper to adjust to the effects of global warming than it is to try to avert global warming.

Discussion

Faculty often list the development of critical thinking skills as a major outcome of their undergraduate courses. In spirit, most agree that to think critically about an argument, or set of arguments, one must evaluate often conflicting evidence to decide on what is "better" or "worse" based on criteria developed through experience and practice. However, learning to think critically is more than an instructional goal. It requires students to fundamentally shift their epistemological views. The key to developing critical thinking skills in any classroom is to recognize the developmental process in students, and guide them through the early steps, so that they will then be able to analyze information in ways that scientists think is appropriate. Given the widespread public debate on arguments even where scientists are more or less in agreement (global warming, evolution/creation) we can see that higher education has not been very effective in promoting critical thinking skills and that many members of society are still in the position of "When authorities say there is uncertainty, all opinions are equally valid."

Perry Scheme Background

Perry (1970) conducted longitudinal interviews with Harvard undergraduates during their four years of college over a fifteen year period. Using this research, Perry created a model that tracks student development from simplistic ideas about knowledge to a more sophisticated contextual understanding. This scheme has been refined and reworked since its initial publication (Baxter Magolda, 1999, 2001; Belenky et al., 1986; Nelson, 1999) but this original model is still considered to be widely applicable to college students, regardless of socio-economic background, gender, or race.

References for Cognitive Development and Assessment

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Use Simple Classroom Assessment Techniques (CAT) to Check Understanding Along the Way

What is a fair test? Sample in-class CAT:

Scientists think that a *fair test* is one that:

a) Could have shown either of the alternatives to be probably wrong or probably correct.

b) Is based on a line of data or reasoning independent of those on which each of the alternatives is based.

c) Yields a lot of data

d) Contradicts popular ideas

e) Supports their own, preferred answers

f) All of the above

g) None of the above

h) Two of the above