Teaching Critical Thinking:
Lessons from Cognitive Science

Tim van Gelder

Department of Philosophy
University of Melbourne
Parkville VIC 3052
www.arts.unimelb.edu.au/~tgelder

Austhink
Level 50, 120 Collins St
Melbourne VIC 3000
www.austhink.org

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1 Introduction

Surprise quiz: why, except during a full moon, is part of the Moon in shadow?

The most common answer to this question, even among smart undergraduate students at the best institutions, is something like this: the Earth blocks light from the Sun, causing a shadow, and the Moon happens to sit on the boundary of that shadow; hence part of the Moon is lit up while the other part is in darkness.

This answer is, of course, wrong. It reflects a widely held misconception about basic astronomy. More interestingly, it dramatically illustrates a typical failure to think critically. Students are unaware that they have in mind an explanatory hypothesis as to the existence of shadow on the Moon; and that before accepting that hypothesis as true, they ought to compare it with other hypotheses. Another hypothesis in this case is that we are seeing the Moon from its side (assuming the Moon's "front" is facing the sun), and the darkness is the shadow the Moon necessarily creates on itself – the "dark side of the Moon". To see how this works, hold up a tennis ball near a bright light; the shadow, and the reason for it, is obvious! When comparing these two hypotheses, people immediately see that the second one is more likely to be true, and that they had accepted the first without really thinking about it – that is, *uncritically*.

Almost everyone agrees that one of the main goals of education, at whatever level, is to help develop students' general thinking skills, including in particular their *critical* thinking skills. Almost everyone also agrees that students do not acquire these skills as much as they could and should. Indeed, as Deanna Kuhn put it,

> Seldom has there been such widespread agreement about a significant social issue as there is reflected in the view that education is failing in its most central mission—to teach students to think.[1]

The difficult part is knowing what to do about this problem. It seems obvious that we need to improve our teaching, and our educational systems more generally. But in what way? What kinds of reforms would best promote the development of critical thinking skills?

My approach to this question is unashamedly "scientistic" or "positivist" in the sense that it turns straight to science for guidance. The relevant science in this case is *cognitive* science, the interdisciplinary science of thinking: what it is, how it works, and how it develops. Cognitive science is the best source we have for genuine knowledge about "what works and why" in teaching critical thinking.

I don't think that cognitive science is, by any means, the full story. For one thing, cognitive science is incomplete and in a continual state of flux. We have to take its lessons as provisional insights, not as the final word. For another, cognitive science gives us general or theoretical information. It doesn't give us any kind of detailed recipe for actual teaching practice. Its results must be carefully blended with the practical wisdom teachers have accumulated, both as a profession and as experienced individuals.

But what does cognitive science actually tell us about teaching critical thinking? I have summarized in seven succinct "lessons" what I take to be some of the most important ideas. The lessons are partly about critical thinking itself, partly about how

[1] Kuhn, D. (1991). *The Skills of Argument*. Cambridge: Cambridge University Press p.5.

critical thinking skills are acquired, and partly about how critical thinking is best taught. The list should not be regarded as definitive; there are other important results from cognitive science, and somebody else might make a different list. The lessons are aimed at teachers who:

- are keen to do whatever they can to assist their students strengthen their critical thinking;
- understand roughly what critical thinking is, but probably haven't investigated the matter closely
- are not familiar with cognitive science, particularly those parts of cognitive science bearing most directly upon critical thinking instruction

With a brief description of each of the lessons, I have included a "teaching tip" and some pointers to further reading. The teaching tip is not meant to be an exhaustive guide to pedagogical redesign. Rather, each tip is just an idea or two which seem to work for me, and which might also be useful to you - or might not, depending on your teaching situation.

1.1.1 Further reading

Bruer, J. T. (1993). *Schools for Thought: A Science of Learning in the Classroom*. Cambridge MA: MIT Press.

2 What is critical thinking?

A sensible place to start is with the notion of critical thinking itself. There are lots of definitions around, and most involve such notions such as belief, truth and accuracy. Roughly speaking, critical thinking is thinking which helps you figure out whether you should believe some claim, and how strongly you should believe it.[2] Since you should only believe what is true, critical thinking is, as I like to say, *the art of being right*.

But what sort of thinking is that? For practical purposes, it amounts to applying simple guidelines and procedures in deciding how sure you are that a given claim is true. These guidelines and procedures are completely general; they apply equally well in almost any topic, domain or context.[3] For example, the critical thinker knows that if somebody presents a reason to accept a position, that reason probably involves unstated assumptions which should be exposed and questioned. The

[2] Critical thinking can also be directed to what you should *do* (rather than believe). However this can be regarded as covered by a belief-oriented definition, since for every thing you might do, there is a corresponding claim that you should do that thing.

[3] Some philosophers have held that there are no such general guidelines and procedures, and hence there is no such thing as critical thinking as a domain-neutral discipline. Other philosophers have held that there are no chairs, no minds, and no world outside our minds.

critical thinker knows how to go about doing this in a systematic way; and knows how to go about dozens of other such things, including the kind of hypothesis-testing mentioned above.

Critical thinking, defined this way, need not be negative, destructive or “criticizing” thinking; often it is a very positive activity, producing genuine knowledge and satisfying feeling of justified confidence in that knowledge. It is also not opposed or hostile to creative or lateral thinking. Edward de Bono usefully suggested thinking of critical and creative thinking as a car’s left and right front wheels; the car goes nowhere unless both are present and doing their job.

2.1.1 Further reading

Facione, P. A. (1998). Critical Thinking: What It Is and Why It Counts. Available from http://www.insightassessment.com/pdf_files/what&why98.pdf

Fisher, A., & Scriven, M. (1998). *Critical Thinking: Its Definition and Assessment*: EdgePress.

Critical Thinking On The Web: A Directory of Quality Online Resources. http://www.philosophy.unimelb.edu.au/reason

3 Lessons from Cognitive Science

So, what does cognitive science tell us about teaching critical thinking?

Perhaps surprisingly, critical thinking is not something cognitive scientists study much, at least as a topic in its own right. This is partly because the topic is rather too broad and open-ended to be captured by the cognitive scientist’s tightly-focused techniques. Partly also, I think, it is because critical thinking in general is a neglected topic, despite its importance and broad relevance.

But this does not mean cognitive science has nothing to contribute. Cognitive scientists have developed some very general insights into how we think and how we learn, and these can be carried over to the case of critical thinking. They have also studied closely many phenomena which are particular aspects or dimensions of critical thinking. The following “lessons” draw from both these sources.

3.1 Lesson 1: CT is hard

The first and perhaps most important lesson is that critical thinking is *hard*. It can seem quite basic, but it is actually a complicated business, and most people are just not very good at it.

The best research on this topic is the huge study conducted by Deanna Kuhn and reported in her important book *The Skills of Argument*. Kuhn took a diverse selection of 160 people and in extended, structured interviews gave them every opportunity to demonstrate their ability to argue in support of their own opinions. She gathered a huge amount of data, which I summarize as follows: *a majority of people cannot, even when prompted, reliably exhibit basic skills of general reasoning and argumentation*. For example, most people, when asked, have an opinion on a topic like why some kids stay away from school. A typical opinion would be something like *some kinds stay away from school because their parents do not provide discipline*. But when asked to *justify* their opinion – to provide some evidence to back up their opinion – over half the population cannot provide any evidence at all. They will say plenty of stuff in response to the request for evidence, but what they say is not in fact evidence (let alone *good* evidence). Such people are not totally incapable of engaging in reasoning; they can easily follow, or produce, elementary inferences, such as *you don't have a ticket, therefore you can't go in to the theatre*. The problem is that they do not have a general grasp of the notion of evidence, and what sort of thing would properly count as providing evidence in support of their view on a non-trivial issue like truancy.

Humans are not *naturally* critical thinkers; indeed, like ballet, it is a highly contrived activity. Running is natural; nightclub "dancing" is natural enough; but ballet is something people can only do well with many years of painful, expensive, dedicated training. Evolution didn't intend us to walk on the ends of our toes, and whatever Aristotle ("Man is a rational animal") might have said, we weren't designed to be all that critical either. Evolution doesn't waste effort making things better than they need to be, and homo sapiens evolved to be just logical enough to survive while competitors such as Neanderthals and mastodons died out.

So if humans aren't naturally critical, what kind of thinkers are they? Michael Shermer describes us as "pattern-seeking, story-telling animals." We like things to make sense, and kinds of sense we grasp most easily are simple, familiar patterns or narratives. The problem arises when we don't spontaneously (and don't know how to) go on to ask whether an apparent pattern is really there, or whether a story is actually true. That is, we tend to be comfortable with the first account which "seems right"; we don't go on to challenge whether that account really gets things right. Educational theorist David Perkins described this as a "makes-sense epistemology"; in empirical studies, he found that students tend to

> act as though the test of truth is that a proposition makes intuitive sense, sounds right, rings true. They see no need to criticize or revise accounts that do make sense – the intuitive feel of fit suffices.

But even if humans were naturally inclined to think critically, it would still be a hard thing to master, because it is what cognitive scientists call a *higher-order skill*. That is, critical thinking is a complex activity built up out of other skills which are simpler and easier to acquire. For example, to respond critically to a letter to the newspaper, you must already be able to read and understand the letter (text comprehension), which is built in turn out of skills such as being able to recognize words, which in turn… If these lower-level skills aren't properly bedded down, critical thinking just isn't going to happen. You may as well ask your dog to answer your emails.

Further, even if the lower-level skills have been mastered, they have to be combined in the right way. With critical thinking, as with so many other things, the whole is definitely more than the mere aggregate of its parts. Think about tennis, which is a higher-order skill. To be able to play tennis, you have to be able to do things like run, hit a forehand, hit a backhand, and watch your opponent. But it is not enough to master each of these things on its own as an independent unit. You have to be able to combine them into coherent, fluid assemblies (playing a whole point). Likewise, critical thinking involves skilfully exercising various lower-level cognitive capacities in integrated wholes.

Because critical thinking is so difficult, it takes a long time to become any good at it. As a rule of thumb, my guess is that mastering critical thinking is about as difficult as becoming fluent in a second language. Remember all that effort you put into learning – or trying to learn – French or German or Mandarin back at school? Well, that's roughly how hard it is to become a good critical thinker.

3.1.1 Teaching Tip

Don't look for "magic bullets". Your students will not become Carl Sagans overnight; and no fancy new technology or teaching technique is going to produce dramatic transformations without much time and effort also being applied. Don't be discouraged by slow progress. For your students, critical thinking is more of a life-time journey than something picked up in a two-week module in Year 11. However, just because mastery takes such a long time, it is never too early – or too late – to start working on it. Take satisfaction in genuine, if small, steps towards the overall goal.

3.1.2 Further Reading

Kuhn, D. (1991). *The Skills of Argument*. Cambridge: Cambridge University Press.

Perkins, D. N., Allen, R., & Hafner, J. (1983). Difficulties in everyday reasoning. In W. Maxwell & J. Bruner (Eds.), *Thinking: The Expanding Frontier* (pp. 177-189). Philadelphia PA: The Franklin Institute Press.

3.2 Lesson 2: Practice makes perfect

Critical thinking may be hard, but it is certainly not impossible. Some people do get quite good at it. What does this take?

The key is hidden behind the little word "skill." As mentioned, critical thinking is a higher-order cognitive *skill*. Everyone knows, typically, that mastering a skill takes practice, and lots of it. "Practice makes perfect" is nugget of folk wisdom which has been extensively investigated by science, and it has come out vindicated: you won't get better without practice, and getting really good takes *lots* of practice. The skills involved in critical thinking are no exception.

This has one immediate implication for teaching critical thinking. If students are going to improve, they have to actually engage in critical thinking itself. It is not enough to learn *about* critical thinking. Many college professors seem unaware of this point; they teach a course on the *theory* of critical thinking, and assume that their students will end up better critical thinkers. Other teachers make a similar mistake: they expose their students to examples of good critical thinking (e.g., showing a video in which scientists figure out something about our prehistoric ancestors), hoping that students will automatically learn by imitation. These strategies are about as effective as working on your tennis by watching Wimbledon. Unless the students are actively doing the thinking themselves they'll never improve much.

The scientists who study skills haven't simply rediscovered folk wisdom. They have learnt quite a bit about the nature and quantity of the practice needed for mastery. The foremost expert in this area is Karl Anders Ericsson, who with his colleagues has studied at great length how the very top people in many different fields become as good as they are. He has found that excellence results primarily from a special sort of practice, which he calls "deliberate":

- it is done with full concentration, and is aimed at generating improvement
- it is not just engaging in the skill itself, but also doing special exercises which are designed to improve performance in the skill
- it is graduated, in the sense that practice activities gradually become harder, and easier activities are mastered through repetition before harder ones are practiced
- there is close guidance, and timely, accurate feedback on performance.

Ericsson found that achieving the highest levels of excellence in many different fields was strongly related to quantity of deliberate practice. Interestingly, Ericsson even found a remarkable uniformity across fields in the amount of practice required to reach the very highest levels; it generally takes about ten years of practicing around four hours a day.

On reflection, there is nothing particularly surprising about these results; the importance of practice of this sort is very much what you would expect to hear from your old-fashioned piano teacher.

Although Ericsson didn't study critical thinking specifically, it is reasonable to assume that his conclusions will also hold true for critical thinking. This means that your students will improve their critical thinking skills most effectively just to the extent that they engage in lots of deliberate practice in critical thinking. Crucially, this isn't just thinking critically about some topic (e.g., being "critical" in writing a history essay). It also involves doing special exercises whose main point is to improve critical thinking skills themselves.

Thus critical thinking can't be treated as just a kind of gloss on educational content made up of other "real" subjects. Students will not become excellent critical thinkers merely by doing history or biology, even if such subjects are given a "critical" emphasis (as they should be). Critical thinking must be studied and practiced in its own right; it must be an explicit part of the curriculum.

3.2.1 Teaching Tip

Make sure your students practice critical thinking. They have to actually engage in critical thinking itself, not just learn about it or observe others do it. And make sure at least some of your students' practice is on special activities specifically designed to help improve their critical thinking skills. Keep in mind the sporting analogy: to get really good at tennis, you have to play lots of tennis, but that's not enough; you also have to do special tennis exercises.

3.2.2 Further Reading

Ericsson, K. A., & Charness, N. (1994). Expert performance. *American Psychologist, 49*, 725-747.

3.3 Lesson 3: Practice for Transfer

One of the biggest challenges in learning new skills, particularly general skills like critical thinking, is what is known as the problem of transfer. In a nutshell, the problem is that an insight or skill picked up in one situation isn't, or can't be, applied in another situation. For example, if someone has just learnt how to calculate the per-kilogram price for packaged nuts, they should then be able to calculate the per-kilogram price for packaged chips; if they can't, we'd say that the learning has failed to transfer from nuts to chips.

Transfer of acquired knowledge and skills certainly does occur to some extent; otherwise, education would be largely futile. The problem is that it tends to happen much less than you'd naively expect. One of the early investigators in this field, E.L. Thorndike, gloomily concluded:

> the mind is so specialized into a multitude of independent capacities that we alter human nature only in small spots, and any special school training has a much narrower influence upon the mind as a whole than has commonly been supposed.

The problem of transfer affects critical thinking as much as any other skill. Indeed, critical thinking is especially vulnerable to the problem of transfer, since critical thinking is intrinsically *general* in nature. Critical thinking skills are by definition ones which apply to a very wide range of topics, contexts, etc., and so there is plenty of territory they can fail to transfer to.

The closest thing we have to a solution to the problem of transfer is just the recognition that there is a problem and it must be confronted head-on. As critical thinking expert Dianne Halpern put it, we must "teach for transfer." We cannot simply hope and expect that critical thinking skills, once learned in a particular situation, will spontaneously be applied in others. Rather, students must also practice the art of transferring the skills from one situation to another. If they can master that higher-order skill of transfer, then by definition they don't have a problem of transfer for the primary skill.

This might sound a bit mysterious, but it can often be quite straightforward. For example: first, have students practice a primary critical thinking skill in some specific context, such as assessing the credibility of authors of letters in the day's newspaper. But don't stop there! Next, get them to abstract for themselves what they've been doing, in such a way that they can see that they had been doing something general which just happened to have been applied to authors of letters. Then, challenge them to identify some *other* context or domain in which that abstracted skill might be properly applied, *and go ahead and apply it*. For example, a student might recognize that the credibility of the author of the textbook being used in another of their subjects is something which can be assessed.[4]

3.3.1 Teaching Tip

To confront the problem of transfer, students must practice transfer itself. Have your students practice carrying a particular general critical thinking procedure over into many different domains and contexts. For example, a vital critical thinking skill is anticipating objections to your position on an issue. Have students consider their positions on a range of different issues, and on each topic, identify objections. Then have them identify objections to their positions in a range of different situations, e.g., when writing an essay, when answering a question in class, or when involved in an out-of-class dispute.

3.3.2 Further Reading

Halpern, D. F. (1998). Teaching critical thinking for transfer across domains. *American Psychologist, 53*(4), 449-455.

3.4 Lesson 4: Practical Theory

Many people enjoy a beer, but few know much about beer itself. Even people who consume lots of beer typically don't know all that much about it. They are in this sense unsophisticated beer drinkers.

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[4] If it is a good textbook, the author should be come out as being credible; this sort of assessment is not knee-jerk skepticism but reflective consideration according to relevant criteria.

Of course, there's nothing intrinsically wrong with that. There is no obligation - moral, social, intellectual or otherwise - to know the difference between hops, barley and wort. However, if you *do* choose to get into beer (as opposed to getting beer into you) you'll usually find that you can appreciate your beer more. Further, knowing about beer will allow you to do things you cannot otherwise do – for example, match beer with food to enhance both, produce your own beer, or even run your own micro-brewery.

Getting into beer is in part learning what, in an academic vein, we might call the *theory* of beer. You have to learn a new vocabulary, i.e., new words and the corresponding concepts; and understanding the concepts means mastering a body of knowledge, including relevant parts of chemistry and biology. For example, the word "dry" has a special meaning for beer people. It doesn't, of course, mean "not wet." Nor does it have the folk-sophisticate meaning – something like "not sweet and heavy." Rather, in beer-talk, "dry" refers to beer with little or no after-taste, achieved by through a longer-than-usual brewing process in which the yeast consumes more of the natural sugars produced by the fermenting grain.

Now, the point of all this talk about beer is just to introduce by analogy a fundamental point about critical thinking, which is that beyond a certain point, improvement demands getting some theory on board. Just as serious beer drinker knows quite a bit of the theory of beer, so the critical thinker understand the theory of critical thinking. This means acquiring the specialist vocabulary of critical thinking. Instead of saying "That argument sucks," the critical thinker can say that she doesn't accept the conclusion, even though she grants the premises, because the inference is an example of the fallacy of *post hoc ergo propter hoc*.

What's so good about having the theory? Why does it help critical thinking improve?

- Knowledge of the theory allows you to *perceive* more of what is going on. In the case of beer, understanding the vocabulary of beer flavours helps you distinguish flavours which, while always present, are invisible to the naïve drinker. So also in critical thinking: command of the "lingo" is like having a set of x-ray goggles into thinking. For example, if you know what *affirming the consequent* is, you can more easily spot examples of poor reasoning, because reasoning which fits that particular pattern will be more likely to jump out at you.
- This improved insight is the basis for self-monitoring and correction. As described above, improvement requires lots of deliberate practice, i.e., practice aimed at improvement. The better you can "see" what is going on, the more effectively you can understand what you are doing and how you can do it better.
- Similarly, a grasp of the theory provides the foundation for explicit guidance and feedback from a teacher or coach. Instructions have to be expressed verbally, and the more nuanced the vocabulary, the more can be

> communicated. The student who doesn't understand what you're saying about critical thinking can't follow your instructions or respond to your feedback; they can't be guided by you, beyond a certain point.

I suggested above that college instructors often make the mistake of thinking that they can teach critical thinking skills by teaching the theory of critical thinking. But the real mistake isn't teaching theory as such. Grasp of theory is an absolute necessity for advanced critical thinking. The mistake, rather, is to *only* teach theory, or to *overemphasize* theory relative to practice. The mistake is to think that skills are a natural outcome of theory. They are not; skills naturally develop through practice. However that practice is more effective when supplemented by appropriate levels of theoretical understanding.

If you like, a bit of theory is like the yeast which makes bread rise. You only need a small amount, relative to the other ingredients; but that small amount makes all the difference. Note also that if you have nothing but yeast, you have no loaf of bread at all.

You might be thinking, as you read this, that it is stating the obvious; *of course* students need to learn something about critical thinking if they are going to get better at it! And I agree that this point is common-sense. However it is still sufficiently important to be worth including on this list of major lessons from cognitive science, because *in actual practice*, we don't provide students with any, or nearly enough, theory of critical thinking.[5] Most students, it seems, stumble through their entire school and college educations without ever learning much about what they are trying to do.[6] Whatever we might find obvious when we reflect on how skills are acquired, in fact the way we generally go about cultivating critical thinking is to expect that students will somehow pick it all up without the benefit of explicit theory. The lesson from cognitive science is that if you want students to substantially improve their skills, you will at some point need to help them develop theoretical understanding as a complement to the crucial hands-on know-how. As Deanna Kuhn put it,

> The best approach, then, may be to work from both ends at once – from a bottom-up anchoring in regular practice of what is being preached so that skills are exercised, strengthened, and consolidated as well as from a top-down fostering of understanding and intellectual values that play a major role in whether these skills will be used.[7]

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[5] This comment refers to the vast majority of students who never take any dedicated critical thinking instruction such as a first-year undergraduate subject.

[6] This point is elaborated at length in Graf, G. (2003). *Clueless in Academe: How Schooling Obscures the Life of the Mind*. New Haven, CT: Yale University Press.

[7] Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher, 28*(2), 16-26.

3.4.1 Teaching Tip

If you can't do a whole unit or subject on critical thinking, at least spend the occasional class looking explicitly at theoretical aspects of critical thinking. You can be modest in your ambitions; the important thing is that students understand the theory, can pick up the relevant vocabulary, and can see how the theory relates to what they are doing in other contexts. For example, spend a class on the distinction between *evidential* reasons (reasons providing evidence that a claim is true) and *explanatory* reasons (reasons which assume the claim is true, and go on to explain how or why the situation came about). Just about any good textbook on critical thinking will be a good source of material.

3.4.2 Further Reading

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher*, 25(4), 5-11. Available online at http://www.andrew.cmu.edu/~reder/paper/96_jra_lmr_has.html

There are many good textbooks containing lots of useful theory. Three good ones are Salmon, M. (2001). *Introduction to Logic and Critical Thinking* (4th ed.): Wadsworth; Halpern, D. F. (2002). *Thought and Knowledge: An Introduction to Critical Thinking* (4th ed.). Hillsdale, N.J.: Lawrence Erlbaum Associates; and Schick, T., & Vaughn, L. (1995). *How to Think About Weird Things*. Mountain View, CA: Mayfield.

3.5 Lesson 5: Belief Preservation

Francis Bacon, the great seventeenth-century philosopher of science, once said

> The mind of man is far from the nature of a clear and equal glass, wherein the beams of things should reflect according to their true incidence; nay, it is rather like an enchanted glass, full of superstition and imposture, if it be not delivered and reduced.[8]

In other words, the mind has intrinsic tendencies to illusion, distortion, and error. To some extent, these are just features of the "hard wired" neural equipment we inherited through the accidental process of evolution. To some extent, they are the result of common patterns of growth and adaptation – the way our brains develop as we grow up on a planet like Earth. And to some extent, they are "nurtured," i.e., are inculcated our societies and cultures. Yet whatever their origin, they are universal and ineradicable features of our cognitive machinery, usually operating quite invisibly to corrupt our thinking and contaminate our beliefs.

These tendencies are known generically as "cognitive biases and blindspots." They are obviously important for the critical thinker, who ought to be aware of them and

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[8] Bacon, F. (1974). *The Advancement of Learning, and New Atlantis*. Oxford: Clarendon.

either eliminate them entirely, if possible, or at least compensate for their influence, much as a skilful archer adjusts her aim to allow for a breeze. We use the term "critical metacognition" for the process of actively monitoring and controlling one's thinking (meta-cognition) in order to improve judgment (critical) as a way of counteracting the pernicious influence of cognitive biases and blindspots.

There are literally dozens of biases and blindspots, some operating as powerful traps, others as subtle tendencies. An introduction to critical metacognition could easily occupy this whole essay, but here I will discuss just one bias, one of the most profound and pervasive of the lot: *belief preservation*. At root, belief preservation is the tendency to make evidence subservient to belief, rather than the other way around; or, put another way, to use evidence to *preserve* our opinions rather than guide them. It is nicely illustrated by this story from Stuart Sutherland:

> When I was quite young, I conducted a routine piece of motivation research on a well-known brand of gin. I interviewed people throughout Britain to obtain their reactions to the bottle and label, and to ascertain the product's 'brand image'. I gave an oral presentation of my results to a party from the distiller's company, which was headed by the managing director, a large bluff Scotsman. When I said anything with which he agreed, he would turn to his colleagues and announce with much rolling of r's, 'Dr. Sutherland's a very smart man. He's absolutely right.' When, however, my findings disagreed with his own views, he said 'Rubbish. Absolute rubbish.' I need never have undertaken the study, for all the notice he took of it.[9]

When we strongly believe something (or strongly desire it to be true) then we tend to do the following things:

- We seek out evidence which supports what we believe, and don't seek, avoid or ignore evidence which goes against it. For example, the socialist seeks evidence that capitalism is unjust and ill-fated, and ignores or denies evidence of its success; the capitalist tends to do exactly the reverse.
- We rate evidence as good or bad, depending on whether it supports or conflicts with our belief. That is, the belief dictates our evaluation of the evidence, rather than our evaluation of the evidence determining what we should believe. For example, Bjorn Lomberg's recent book *The Skeptical Environmentalist* presented lots of evidence running counter to standard "green" positions. Predictably enough, when reviewing the book, environmentalists tended to regard the data and arguments as much worse than did their anti-environmentalist counterparts.

[9] Sutherland, S. (1992). *Irrationality: The Enemy Within*. London: Penguin, p.134.

- We stick with our beliefs even in the face of overwhelming contrary evidence, as long as we can find at least some support, no matter how slender. A dramatic example from the WWII is Stalin's calamitous insistence that Hitler was not going to invade the Soviet Union, despite the clear evidence of German forces massing on the border. Stalin's mistake was not that he had no basis for thinking Hitler would not invade; rather, it was failing to surrender that belief when that basis was outweighed by contrary indications.

Belief preservation strikes right at the heart of our general processes of rational deliberation. The ideal critical thinker is aware of the phenomenon, actively monitors her thinking to detect its pernicious influence, and deploys compensatory strategies. Thus, the ideal critical thinker

- puts extra effort into searching for and attending to evidence which contradicts what she currently believes
- when "weighing up" the arguments for and against, gives some "extra credit" for those arguments which go against her position;
- cultivates a willingness to change her mind when the evidence starts mounting against her

Activities like these do not come easily. Indeed, following these strategies often feels quite perverse. However, they are there for self-protection; they can help you protect your own beliefs against your tendency to self-deception, a bias which is your automatic inheritance as a human being. As Richard Feynman said, "The first principle is that you must not fool yourself—and you are the easiest person to fool."

3.5.1 Teaching Tip

Encourage students to counter belief preservation by actively exploring the evidence going against their beliefs. Have them play "Devil's Advocate," arguing the case against their own side. Have them participate in structured debates, in which they are either arguing the case against what they antecedently believe, or at least must anticipate and respond to that case when made by the other side.

3.5.2 Further reading

Sutherland, S. (1992). *Irrationality: The Enemy Within*. London: Penguin, chapters 10, 11.

van Gelder, T. J. (1999). "Heads I win, tails you lose": Desire's hold over reason. *Quadrant,* July-August, 15-19. A version is available online at http://www.arts.unimelb.edu.au/~tgelder/papers/HeadsIWin.pdf

3.6 Lesson 6: Map it out

A core part of critical thinking is handling arguments. By "argument" here I don't mean an angry dispute; rather, I'm using the term the way logicians do, to refer to a logical structure. As defined in the classic Monty Python sketch 'The Argument Clinic',

> A: An argument is a connected series of statements intended to establish a definite proposition.
>
> B: No it isn't.
>
> A: Yes it is!
>
> etc.

Arguments constitute a body of evidence in relation to some proposition (idea which is true or false). The proposition is expressed in some claim (e.g., the claim that *Houdini was a fraud*) and the evidence is expressed in other claims (e.g., *Nobody could have escaped from a locked trunk under a frozen river*.) The evidence can form a complex web or hierarchy, with some claims both supporting others and being supported by further claims (e.g., *Nobody could have escaped from a locked trunk under a frozen river* may itself be supported by further claims).

There is a feature of the way we handle arguments which is so automatic and pervasive that it is almost invisible: arguments are presented or expressed in *prose*. By "prose" I mean just ordinary text, whether written or spoken. Here are some examples of expressing arguments in prose:

- Writing letter to the editor in a newspaper, arguing for a certain point.
- Publishing article in a journal, defending a position in an academic debate.
- Making speech in parliament making the case for some new law
- Arguing your position in a family dispute around the kitchen table.

In all these cases, and endless others like them, the argument (the abstract logical structure) is expressed in sequences of words or sentences which stream out either as ink on the page (written prose) or as sounds in the air (spoken prose). Prose, in short, is "one damn word after another."

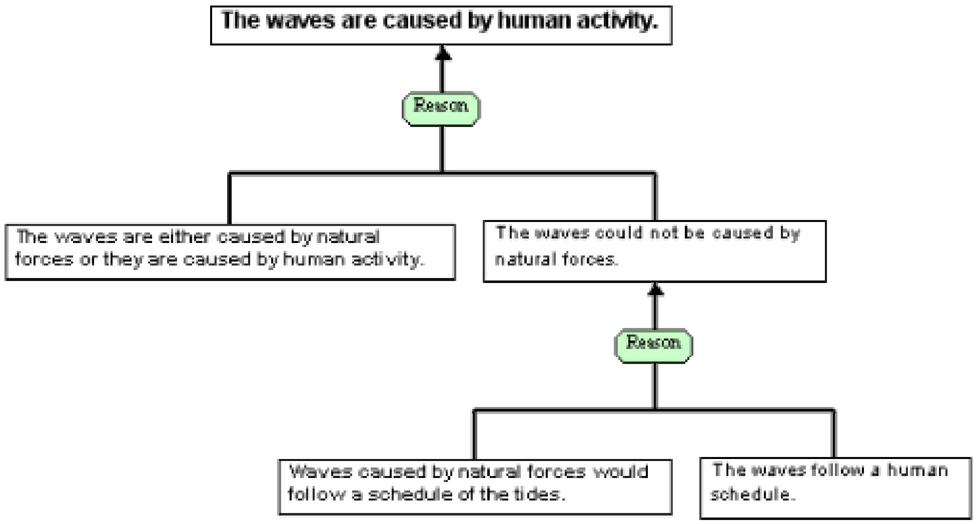
Since an argument is a "connected series of statements," nothing could be more natural, it seems, than expressing the argument in a sequence of sentences. Indeed, most people haven't the faintest idea that there is any alternative. However there *is* an alternative, one that is obvious enough after a little reflection. If evidence forms complex hierarchical structures, then those structures can be *diagrammed*. Put another way, we can draw *maps* which make the logical structure of the argument completely explicit.

For example, consider the following passage:

> The scientists determined that the waves could not be coming from natural forces because those would follow a schedule of the tides.

> Instead, it must be human activity, said Dr. Michael S. Bruno. "It's something we're doing because it's following our schedule," he said.[10]

The passage expresses *in prose* an argument about the origin of some unusual waves. Here is the same argument (or at least, what I take to be the argument) expressed in an argument map:



This particular diagram, of course, uses a distinctive set of conventions.[11] One is that the main point being argued for is put at the top (or, more technically, at the root of the argument "tree"). The arrows indicate that one claim, or group of claims, is evidence in relation to another; the word "Reason" indicates that they are supporting evidence. The lines which join together indicate that claims belong together as part of one piece of evidence, rather than providing independent pieces of evidence. Once you are comfortable with these conventions, you can immediately "see" the logical structure of the reasoning.

Now, the crucial result from cognitive science is that *students' critical thinking skills improve faster when instruction is based on argument mapping*. The main evidence for this comes from studies where students are tested before and after a one-semester undergraduate critical thinking subject. Students in subjects which are heavily based on argument mapping consistently improve their skills many times faster than students in conventional subjects. In our studies, one semester of instruction based on argument mapping yields reasoning skill gains of the same magnitude as would normally be expected to occur over an entire undergraduate education.

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[10] Adapted from Chang, K. (2002, December 24). Studying waves for smoother sailing. *The New York Times,* Section F, p. 3.

[11] The conventions used here are those found in the Reason!Able software (www.goreason.com).

What is the source of this advantage? From a learning perspective, argument maps have a number of advantages over standard prose:

- They make reasoning more easily *understandable*. Students can focus their attention on the critical thinking, rather than getting bogged down just trying to understand the reasoning as presented in prose.
- Once students can see the reasoning, they can more easily identify important issues, such as whether an assumption has been articulated, whether a premise needs further support, or whether an objection has been responded to.
- When arguments are presented in diagrammatic form, students are better able to follow extended critical thinking *procedures*. For example, evaluating a multi-layered argument involves many distinct steps which should be done in a certain order.
- When arguments are laid out in diagrams following strict conventions, a teacher can immediately "see" what the student is thinking. One instructor has described argument mapping as giving "x-ray vision into the students' minds." This clarity of insight allows the teacher to give much more rapid and targeted feedback, and the student understands better where the feedback applies and what needs to be done to correct problems.

In short, argument maps are simply a more transparent and effective way to represent arguments, and so they make the core operations of critical thinking more straightforward, resulting in faster growth in critical thinking skills.

If argument maps are so great, why are they not used much? An important part of the explanation is that is it is usually just a lot easier to work in the prose medium rather than in diagrams. As a practical matter, representing arguments in diagrams tends to be slow and cumbersome. However this is starting to change, with personal computers ever more widely available, and the emergence of software packages specially designed to support argument mapping.

3.6.1 Teaching Tip

Have your students regularly draw diagrams of their reasoning. For example, if they are doing an argumentative essay, require them to attach to their essay a diagram showing the logical structure of their argument. This will force them to clarify what their argument is, and give you a "road map" to their thinking. Have your students learn how to use a dedicated argument mapping software package such as Reasonable

3.6.2 Further reading

Kirschner, P. J., Buckingham Shum, S. J., & Carr, C. S. (Eds.). (2002). *Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-Making*. London: Springer-Verlag.

Twardy, C. (forthcoming). Argument maps improve critical thinking. *Teaching Philosophy*.

Reason!Able. Educational software. Available from The Reason Group, www.goreason.com

3.7 Lesson 7: Don't Reward

The last lesson is probably the most surprising and counter-intuitive of all, and yet may also be one of the most important: *If you want your students to be excellent critical thinkers, don't reward them*.

What??

Let me explain. In the light of previous sections, it should be clear that students will only really improve if they *want* to be good critical thinkers. Improving critical thinking takes attention and dedication. If students don't *care* about improving, they hardly will. Put another way, students need to be *motivated* to improve.

Motivation comes in two different kinds, known as *intrinsic* and *extrinsic*. Intrinsic motivation is caring about an activity or achievement for its own sake. Do you have a hobby? Then you surely understand intrinsic motivation. A hobby is something you do simply because engaging in the hobby gives you deep satisfaction. You develop interests and goals which are wholly bound up within the activity itself; and the satisfaction comes simply from indulging those interests and achieving those goals.

Extrinsic motivation is caring about an activity or achievement only because it will get you something else, something *extrinsic* to the activity. That "something else" is an extrinsic reward for your efforts. Extrinsic reward is one way to motivate people to do things; it is what you use if no intrinsic motivation is present. When people are intrinsically motivated, they'll do it anyway; indeed, they might pay quite a lot for the privilege, as when people spend a lot of money pursuing their hobbies. If they have no intrinsic motivation, then you might have to pay them, i.e., give them an extrinsic reward.

Now, it turns out that extrinsic motivation is evil stuff. It has all sorts of pernicious consequences. For one thing, it dampens interest and enjoyment. Consider mowing the lawn. For many people, this can be quite satisfying. The outdoor exercise, the smell of cut grass, seeing an untidy lawn made kempt; such people often mow the lawn more than they really need to, because they enjoy it so. Yet if you pay somebody to mow a lawn, the same activity is seen as an unpleasant chore: noise, fumes, sweat, work. A person paid to mow the lawn takes less pleasure in the job and will not do it again unless they have to.

Perhaps worse, extrinsic motivation can even reduce performance. Studies have found that groups of students given extrinsic rewards to engage in some task do *worse* than other groups offered the opportunity to engage in the same tasks for their own satisfaction. The former students seem to have their mind on the reward, not the task. This perverse effect of rewards can affect the quality of students' thinking. In one study, students did more poorly on intelligence tests when provided with rewards for achievement!

These ideas are very general; they apply wherever there is a distinction between intrinsic and extrinsic motivation. However they are especially relevant to education, and to instruction in critical thinking in particular. You, as the teacher, want your students to become excellent critical thinkers, and you understand that this will take considerable effort on their part. It seems the most natural thing in the world to use the various artificial incentives you have at your disposal – that is, to *reward* students for doing critical thinking exercises, or for doing well, by providing them with grades, tokens (eg gold stars) or copious praise. Yet the danger is that these extrinsic motivators may harm your students' prospects in the longer term, even as they succeed in certain ways in the short term. Yes, you *can* encourage students to practice critical thinking, or display critical thinking, by offering them external rewards such as higher grades; however encouraging them in this way may at the same time reduce their interest and enjoyment in critical thinking, make it less likely that they will think critically when not offered such rewards, and even lead them to perform less well – relative, at least, to students whose involvement in critical thinking flows from genuine, intrinsic interest and enjoyment.

An enormous challenge for teachers hoping to improve critical thinking skills is to create the conditions under which students develop *intrinsic* motivation – that is, conditions under which they develop genuine respect for and interest in critical thinking, and want to improve their critical thinking for its own sake, rather than to earn whatever extrinsic rewards the teacher may be able to dangle in front of them. As a teacher, I am pleased enough when I see students perform their exercises correctly and conscientiously in order to receive a good grade. However I am deeply satisfied, indeed thrilled, when I see students spontaneously exploring and applying critical thinking even when no reward from me is on offer.

3.7.1 Teaching Tip

Try to decouple critical thinking from extrinsic rewards. In a school or university context, it is impossible to do this entirely; this is a deep but unfortunate feature of the way we have set up our educational systems. However, you can try to set up critical thinking activities students can enjoy for their own sake, challenges they can test themselves against, and standards they can aspire to meet. Take computer games as a model. Good computer games are successful largely because they set challenges for the user, offering no reward other than the satisfaction of better performance. Often these challenges are genuine *thinking* challenges, proving that students can really enjoy exercising their mental powers.

3.7.2 Further Reading

Kohn, A. (1999). *Punished by Rewards: The Trouble with Gold Stars, Incentive Plans, A's, Praise, and Other Bribes*: Houghton Mifflin.

Gee, J. P. (2003). *What Video Games Have To Teach Us About Learning and Literacy*. New York: Palgrave Macmillan.

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