Computer-supported development of critical reasoning skills[1]

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Appendix 1: Example tutorial exercise

Before working through the design and purpose of this tutorial, some background on the design of the course, and the content chosen for this tutorial, is required. The tutorial concerns Zeno's first paradox of motion. Zeno considers the case of a single moving object (the paradox is often explained using a runner as an example) that is supposed to traverse a finite interval of space in a finite time. Those who think motion *is* possible (Zeno's opponents) think that it *is* possible for an object to do this. Zeno assumed for the purposes of the paradox that space was continuous, i.e. infinitely divisible. He reasons roughly as follows: Before the runner can cover the whole distance, she must get half way. Before she can get half way, she must get half of half way, and so on *ad infinitum*. The preliminary result of this reasoning is that the finite distance is composed of an infinite number of parts, and by arguing that to traverse each part, some finite amount of time is required, Zeno reaches the conclusion that any motion will take forever (the sum of an infinite number of bits of time), and hence that motion is impossible.

Zeno's first two paradoxes of motion (this tutorial only concerns the first – the second is the subject of an additional set of exercises) are relatively easy to explain to undergraduate students. The vast majority of people, including first year students, find their conclusion preposterous. Even so, and consistent with Kuhn's findings as reported above, very few people can say much by way of *objecting* to the actual workings of the argument. Most, that is, stop at the point of rejecting the conclusion and simply feel unhappy about the existence of the argument in favour of it. It is unusual, and pedagogically very useful, that there is an argument provoking rejection that is so strong and unanimous. (Groups of undergraduate students will typically be divided in their views on many controversial questions.) Following a presentation of the argument in lectures in a way that is very sympathetic to Zeno, and hence very offensive to first year students, the lectures turn specifically to describing a choice between two ways of responding to Zeno. One is the 'ignore it' approach, summed up with the line 'I know I reject the conclusion, and I don't care about anything else'. The other is the 'resolution' approach, which attempts to find something wrong with the argument, so that it can be answered and refuted, instead of just being ignored. This part of the lectures involves some 'cheerleading' for the resolution approach, asking students what they think highly educated people are hired to do, what sorts of problems they may be expected to deal in the workplace, and what they would *have to do* if they wanted to defeat a proposed course of action in a company, a political gathering, etc., that they felt was wrong. The task of studying the argument to find out what is wrong

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with it, and come up with objections that *defeat* it is thereby presented as worth attempting, for its own satisfactions, and because it involves acquiring a generally useful skill.

The particular design of the tutorial then facilitates this process of analysis, weighing up of the merits of various reasons and, initially, determining how to deploy ready-made objections to neutralise the argument. Later parts of the exercise encourage taking Zeno's side, and then returning to attempts a refutation.

The tutorial begins from a prepared argument map, which appears below (figure 3).

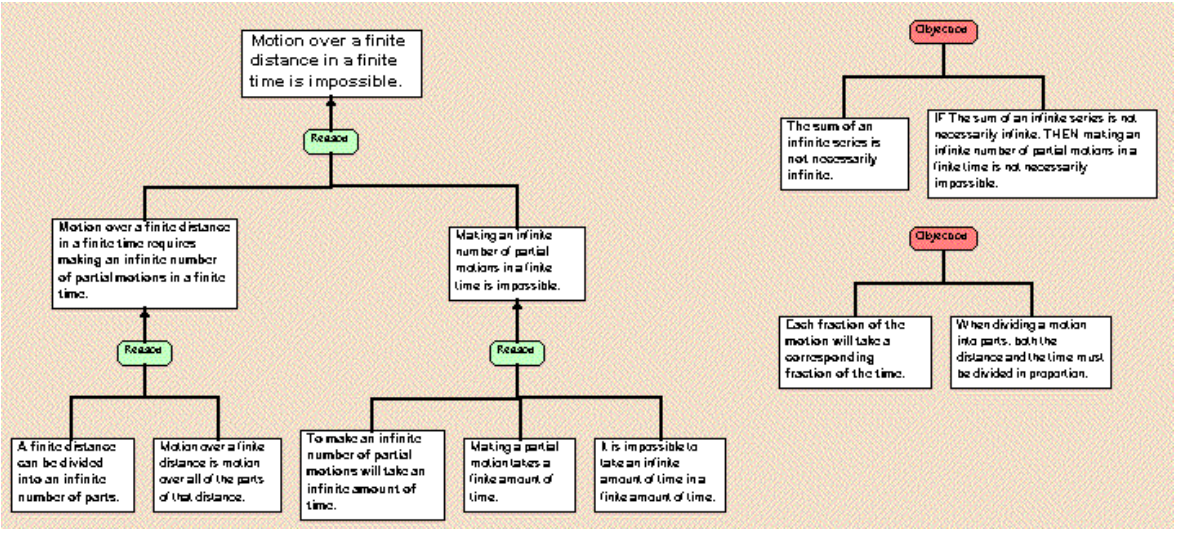

Figure 3: *Reason!Able* argument map for use in a tutorial exercise.

The text in boxes, and set in a different typeface, that follows are the instructions for the tutorial exercise, interspersed with comments and explanation.

Reason!Able Tutorial – Zeno's First Paradox of Motion

Instructions

This structured tutorial exercise relates to an argument map representing Zeno's first paradox of motion. The argument map is available as a Reason!Able file [here].[2] You should have a copy of the argument map in front of you while you complete this tutorial, ideally in the Reason!Able environment. (You may also find it useful to print a copy of the argument so that you can write on it during some of the stages.) There are five stages to the tutorial, and they should be done in order. (There are also some additional, optional, more advanced tasks at the end. If you find that you get through the main tasks quickly and easily, or are working by yourself, you should try at least one of these.)

The argument map has three trees in it. The one on the left provides a set of reasons for the conclusion that "Motion over a finite distance in a finite time is impossible." The two on the right are (when you open the argument) 'floating' objections, in each case with two reasons.

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[2] On the website this would be a link to the *Reason!Able* argument map.

Stage 1: Check that the three arguments observe the 'one statement per box' rule. Consider each box in turn, and check whether what is in it is indeed a statement, and whether it is a single statement.

If a box does not contain a statement, then it is not the sort of thing that can be true or false, and does not belong in an argument. (It may need rewriting to make it into a statement.) If a box contains a complex statement (for example by making two claims, in a compound sentence) then two things that should be evaluated and supported separately are being bundled together, which is not good reasoning.

When you have checked every box, proceed to the next stage.

This tutorial is intended for use near the beginning of the course. In this argument map every box does indeed contain a single, simple statement. In this case the purpose of checking that each box contains only one simple statement, is to help cultivate the habit of applying the first rule listed above. In later and more advanced tutorials, argument maps that violate the rule are sometimes used, and in those cases specific tasks relating to repair of the defect are detailed.

Stage 2: Check the three arguments for 'danglers'. Start at the top of each argument and check that the two parts of each statement in the top box occur in at least one box below. Then check the remaining parts of the statements in the supporting layer, to see whether they link up with one another.

A part of any statement that occurs only once in an argument is a 'dangler' - if it is in a conclusion then it is not supported by the argument, and if it appears in a reason or objection then it is not doing any work in the argument.

When you have checked all three arguments for danglers, proceed to the next stage.

There is only one definite dangler in this argument. The left hand branch of the main argument contains two reasons for a claim that concerns ‘motion over a finite distance in a finite time’, but both of the reasons concern distance but not time. ‘Time’ is a dangler, and this fact is crucial to how Zeno’s argument misleads the audience – he applies one criterion to the division of space, but a different one to the division of time. Not all students spot this dangler, since it is fairly subtle. It is not essential for the progress of the tutorial that everyone notice this dangler. By checking that the argument is mostly clear, students in the tutorial are guided to come to a better appreciation of the structure and logic of the paradox, and are well prepared for the next stage.

Stage 3: Now ask yourself, with reference to each box, whether the statement it contains seems true or false *to you*. Make a note of any statements that seem to you to be definitely true, and any that strike you as suspect, or definitely false.

In order to complete this stage you need to make sure that you know what each statement means.

At this stage do not worry too much about whether or not you can say why you think a statement is true, false, or doubtful. Trust your immediate reaction. Be *very* careful to consider each statement on its own. (This means that when considering statements near the bottom of the argument map on the left, you should not allow your reaction to Zeno's conclusion to affect your judgement. Even if you find his conclusion ridiculous, it is quite possible that *some* of his reasons are true.)

When you have asked yourself of each statement whether you think it true, false, or doubtful, and

made some record of which statements you think are false or doubtful, proceed to the next stage.

This stage is extremely important. The previous two have established that the argument is reasonably solid in structure, with the exception of one dangler that not all will have noticed. But, as noted, the parts of arguments are statements, claims that can be either true or false, and by considering each claim on its own, it may be possible to find a weak spot. Students typically need some guidance and coaching to set aside the wider argument during this stage, and consider each claim on its own. By doing so, though, they adopt the stance of one considering the value of the different components of the argument on their individual merits, and thereby prepare themselves for considering whether any weaknesses undermine the argument as a whole. This stage of the tutorial deliberately relies upon the *hunches* of the individual student. Part of the process of teaching critical reasoning is one of assisting people in making their own hunches more explicit, and focussed.

Stage 4: Try to incorporate the two 'floating' objections into the main argument on the left. Make sure that they are placed so that there are no dangers - if you have placed them correctly there should not be any.

In order to complete this stage of the tutorial you will need to drag and drop the objections onto specific parts of the argument on the left. You can drag and drop repeatedly, to try out different options. For each placement you attempt, check for danglers. When you have found a pair of placements that leave no danglers in either case, proceed to the next stage.

This stage is relatively unusual – our tutorial exercises rarely offer 'ready made' objections of this sort. In this case, though, each objection is part of the standard literature on Zeno. The lower objection is a version of Aristotle's complaint against Zeno's paradox, and the upper one is based on the reaction to the paradox following the beginnings of rigorous treatment of infinity in mathematics. Either objection on its own does very serious damage to the paradox if properly positioned, and the two together are devastating.

Stage 5: Consider whether the placement gives some reason for your views regarding which statements were false or doubtful from stage 3. Hopefully at least *some* of your doubts will now have been turned into proper objections, with reasons.

If there are any questions you still have regarding this exercise do not ignore them. If you are working in a group tutorial, then ask your tutor. If not (or if the tutorial is finishing) then print out the argument map, and try to discuss it with a fellow student, with your tutor, or the course lecturer.

Additional (more advanced) stages:

If you have successfully completed the five stages of the tutorial, you should be ready for some more advanced work with the argument. Here are a few things you might want to try:

- Consider how a supporter of Zeno might object to the objections. (And work out at least one of these - responses as a proper argument, with one statement per box and no danglers.)
- Consider ways of giving reasons *in favour* of the objections.
- Think of at least one more objection to the argument.

- Motion is only one type of change, and Zeno was concerned to argue against the possibility of change in general. Try to make a version of Zeno's argument (with the same general structure) that argues that it is impossible to cook a meal, or count to ten, or grow old. (One of these suggested extensions may turn out to include some significant surprises.)

It is likely, although not guaranteed, that the placement that satisfies the requirements of stage 5 (there are several that do so) will give reasons for initial dissatisfaction found in stage 4. If so, excellent: the tutorial will have helped make possible inchoate hunches explicit, and also helped use them to defeat an annoying argument. If not, then a simple answer (or two answers) to an annoying argument will have been found.

The 'more advanced' stages of the tutorial are not intended to be attempted during the scheduled tutorial, but are there so that students who complete the previous stages unexpectedly quickly have something to challenge them, and as an additional resource that any student can attempt in his or her own time. A very important part of the process of running the tutorial is requiring students to spend a substantial part of the time working in small groups of two or three. Having to talk about the topic, and justify particular proposals about what should be done in the case of any given sub-task is excellent practice in making and assessing arguments.