Computer-Aided Argument Mapping: An Educational Revolution?

Martin Davies

Abstract—Map-mapping has been used for educational purposes for many years. That is nothing new. Mind mapping and concept mapping are both routinely used in higher education contexts. What is new is a variety of software packages that permit more complex forms of map-making. These softwares take advantage of computational power to enhance and augment the natural processing limitations of the human brain. Also new is a specialised form of mapping—argument mapping—dedicated to displaying inferential connections between propositions. Computer-aided argument mapping (CAAM) is a relatively recent innovation that promises to revolutionise the teaching of critical thinking skills. Students can now visually demonstrate their understanding of complex debates by actively engagement in making maps of arguments. Empirical evidence shows that CAAM can significantly improve critical thinking skills with targeted interventions under controlled conditions. Long assumed to be a "wicked" problem, a generic skill that is hard to teach, educators now have available to them dedicated softwares with which to explicitly teach critical thinking as part of the curriculum. This is perhaps not before time, as evidence shows that students are leaving universities without adequate preparation in perhaps the most important skill of all: critical thinking.

Index Terms—Critical thinking, argument making, inference-making, computer-aided argument mapping.

– – – – – – – – – – – – – – – – – – – –

INTRODUCTION

As individuals we often face complex issues about which we must weigh evidence and come to conclusions. Corporations also have to make decisions on the basis on strong and compelling arguments. Legal practitioners, compelled by arguments for or against a proposition, and underpinned by the weight of evidence, are often required to make judgements that affect the lives of others. Medical doctors face similar decisions. Governments make choices in terms of purchasing decisions, for example, for expensive military equipment, or decisions in the areas of public or foreign policy. These issues involve many arguments on both sides of difficult debates. These issues involve understanding the arguments of others, and being able to make objections and provide rebuttals to objections.

Likewise, students in universities deal with arguments all the time. Indeed, a major purpose of a university education—regardless of subject-matter—is to teach students how to read, understand and respond to complex *arguments.* The ability to do this makes for highly employable, adaptable and reflectively critical individuals. We often call the skill of marshalling arguments and assessing them, "critical thinking". All universities claim to instil the skill of critical thinking in their graduates, and routinely note this in their advertising and promotional documents.

CRITICAL THINKING IN UNIVERSITIES: THE PROBLEM

Obtaining well-grounded skills in critical thinking is surprisingly difficult. Research has confirmed what teachers and lecturers already recognise: most people have seriously inadequate critical-thinking skills. In an extensive study of students and the general public, Kuhn (1991) found that people formed opinions readily and held to them strongly but that the majority could not provide any genuine evidence or arguments for these beliefs. Further, they did not realise this was a problem. Students are expected to develop critical-thinking skills during their years of undergraduate education. However, one review concluded that in attending four years of American university the average student only gains somewhere between 0.5 and 0.65 standard deviations (SD) (Hitchcock, 2003), or about 0.08 SD per semester on average—and there is some evidence that much of this is due simply to maturation.

Research on the effectiveness of critical-thinking courses is perhaps even more worrying. McMillan (1987), Halpern (2002) and van Gelder, Bissett, & Cumming (2004) have all found evidence that conventional critical-thinking instruction did not result in gains beyond those due to maturation and university education. In 2000, a leading theorist of critical thinking wrote: "I wish I could say that I had a method or technique that has proved successful. But I do not, and from what I can see, especially by looking at the abundance of textbooks on critical thinking, I don't think anyone else has solved this problem either" (Walton, 2000, p. 36).

Despite the claims by universities in their promotional documents, many students leave schools and universities 'unable to understand, evaluate, or write arguments' (A. A. Larson, Britt, & Kurby, 2009, p. 340). One study, involving fifty-seven native English speaking students found that, without a tutorial on the generic skills of argumentation, college students 'frequently failed to distinguish acceptable arguments from structurally flawed arguments' (p. 358). Another study involving seventy-six native English-speaking tertiary students found that students are 'not skilled at identifying key elements of an argumentative text' and 'were not proficient comprehenders of natural, written arguments' (M. Larson, Britt, & Larson, 2004, pp. 205, 220). Only 30 percent of all participants could identify and distinguish between *claims* (assertions) and *reasons* in a text. Most selected reasons that could not support the claims being made, and mistakenly identified counter-claims as main claims.

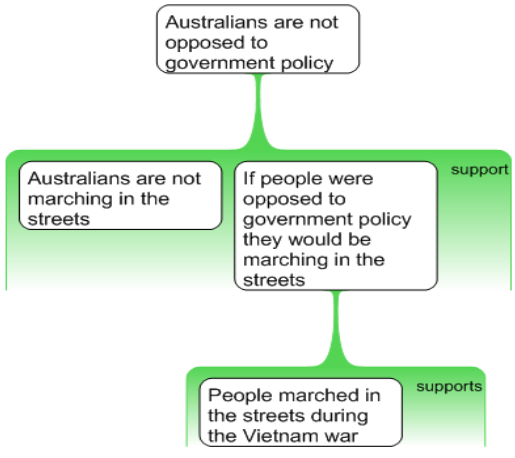
In a major recent study, Arum and Roska found: 'With a large sample of more than 2,300 students, we observe no statistically significant gains in critical thinking, complex reasoning, and writing skills for at least 45 percent of the students in our study. An astounding proportion of students are progressing

through higher education today without measurable gains in general skills as assessed by the CLA [Collegiate Learning Assessment Test]. While they may be acquiring subject-specific knowledge or greater self-awareness on their journeys through college, many students are not improving their skills in critical thinking, complex reasoning, and writing' (Arum & Roksa, 2011, p. 36).

Part of the problem is that arguments are usually expressed in prose. And, prose is, by its very nature, open-textured and sometimes vague. The following argument is fairly clearly expressed (compared to complex, conceptually difficult arguments in the disciplines) but it still takes effort in distinguishing the premises and the conclusion. This is partly because of the surrounding text that masks the argument, and partly because of the lexical density of the prose itself:

> *It is fairly clear that Australians are not – as some might suggest they are – opposed to government policy, for if they were they would be more critical of the government than they are at present. However, there is no evidence of this; there is no evidence that ordinary Australians are protesting against their elected representatives. The case of the Vietnam War was, of course, different. Then there were mass protests, demonstrations and marching in the streets which indicated a clear opposition to government policy.*

Compare this to the following representation of the same argument:



For anyone familiar with the basic conventions, this graphical representation is far easier to interpret correctly.

Academic discourse, of course, compounds the problem of lexical density and the difficulty of ascertaining (from the surrounding verbiage) an author's contention and the reasons leading to it. Take the following authentic example:

> *The move from a structuralist account in which capital is understood to structure social relations in relatively homologous ways to a view of hegemony in which power relations are subject to repetition, convergence, and rearticulation brought the question of temporality into the thinking of structure, and marked a shift from a form of Althusserian theory that takes structural totalities as theoretical objects to one in which the insights into the contingent possibility of structure inaugurate a renewed conception of hegemony as bound up with the contingent sites and strategies of the rearticulation of power.* [1]

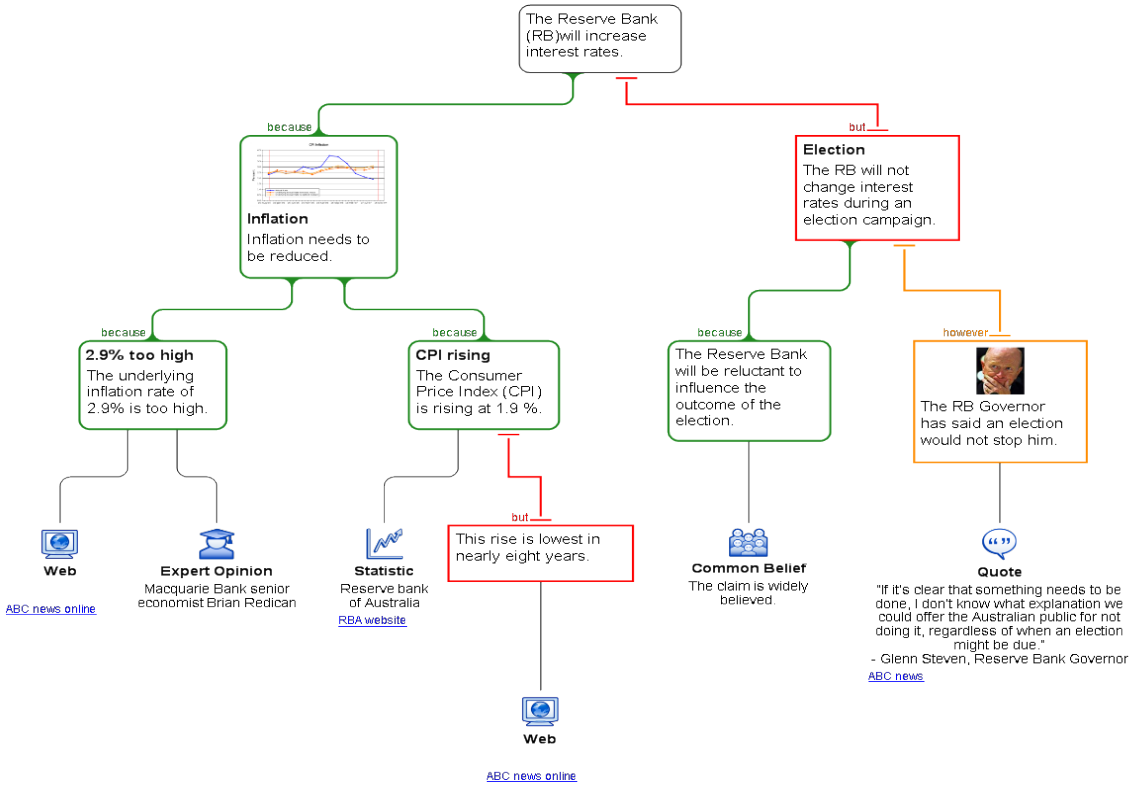
Even if this example had a clear argument (it is not obvious that it does) it would be exceedingly difficult to "map" as reasons leading to a contention. In reading discipline-specific texts such as this, we assume students will, nonetheless, process complex arguments in prose without being taught to do so, and we assume they will "pick-up" critical thinking skills somehow by "osmosis". As the evidence shows, this is clearly is not happening. And perhaps this should not be surprising. Critical thinking is *hard,* even in the case of simple, short, clearly expressed arguments. It is virtually impossible with difficult texts, and long, complex passages of prose. So what can be done?

COMPUTER-AIDED ARGUMENT MAPPING

Argument maps are visual tools that help in understanding, assessing and evaluating arguments. They differ from "mind maps" and "concept maps" in terms of level of detail and degree of precision. Mind maps are largely concerned with associative relationships; concept maps wth relational connections; and argument maps with inferential connections (Davies, 2011).

Argument mapping involves clearly outlining a contention at the top of a map, followed by tiers of reasons and objections. Argument mapping can be augmented with CAAM (Computer-Aided Argument Mapping) software programs that aid the mapping process. Argument mapping can be used in any discipline as every discipline deals with arguments. An example argument map from the discipline of Finance is provided below. This example includes the evidential basis for the terminal premises, which is possible using dedicated software.

[1] This case of impenetrable text was given first prize in the "Bad Writing Contest" conducted by the journal *Philosophy and Literature* in 2008. The example is from Judith Butler, Professor of Rhetoric and Comparative Literature at the University of California (Dutton, 2011).



Example from http://www.austhink.com

EMPIRICAL SUPPORT FOR CAAM

There is empirical support for the use of argument mapping tools in enhancing, retaining and improving knowledge. Evidence from the cognitive sciences shows that visual displays do enhance learning (Vekiri, 2002; Winn, 1991). Maps allow the separate encoding of information in memory in visual as well as propositional form, a phenomenon called "conjoint retention" or "dual coding" (Kulhavy, Lee, & Caterino, 1985; Paivio, 1983; Schwartz, 1988). In simple terms, processing information verbally as well as pictorially helps learning by virtue of using more than one modality. In even simpler terms, map-making helps us to avoid the problem of "cognitive overload". This is intuitively plausible outside of the educational context as well. Faced with having to travel from St. Paul's Cathedral to London Museum, it would be easier to process information on a map, than to be given a long list of complex verbal or written descriptions. The human brain cannot cope with excessive information, and that is why maps are useful. Yet, oddly, despite arguments being the common currency of academic discussion in all disciplines (i.e., propositions for and against contentions), argument maps are seldom used in higher education.

There are also a number of published studies demonstrating empirical support for the use of CAAM in improving critical thinking skills. One study showed that one-subject CAAM-based interventions over a

12-week period achieved a gain in critical thinking abilities of 0.8 SD as measured by pre- and post-test results in the Californian Critical Thinking Skills Test (CCTST). This is roughly similar to a shift from the 50th to the 79th percentile. Astonishingly, this is equivalent to the gains usually achieved in 3 or 4 years of an undergraduate degree (van Gelder, et al., 2004). This CAAM intervention was extensive, and involved weekly expert-led lectures on critical thinking and weekly class-based activities involving argument mapping in tutorials. Similar improvements have been found in other studies ("The Monash Critical Thinking Study," 2009; Twardy, 2004). In Twardy's study, the gains were 90% of the gains in the van Gelder et. al., study under the same conditions, even after controlling for the "teacher effect" and substituting an "inexperienced post-doc" to teach the class, who was unused to argument mapping. In the Monash study, the influence of computer-based feedback in an argument mapping class was trialled over a semester involving weekly 30-40 minute class-based tutorials with regular exercises involving CAAM. They found a CCTST effect size of 0.45 SD, and a 14% average improvement in critical thinking skills. Harrell has found strong gains, especially in students who are weaker in critical thinking to start with (Harrell, 2011). In a very recent study, as little as one hour of instruction in CAAM appears to yield a modest improvement in critical thinking skills (Carrington, Chen, Davies, Kaur, & Neville, 2011).

Data emerging from these studies are uniform in showing an improvement in critical thinking skills in using CAAM; however, the effect size differs depending on the nature, type and extent of the trials. Of course, argument mapping may be taught effectively without computer assistance (i.e., with pen and paper) as found by Harrell (2007). Using software, however, may enhance other aspects of learning, not least of which is student engagement. This is no small thing in the contemporary university, with technologically savvy students who are easily bored with conventional teaching techniques (i.e., lectures, or teacher-centred learning).

CONCLUSION

Why isn't computer-aided argument mapping a more established part of the curriculum? Why do assessment regimes not—as a matter of course—include mapping of arguments (preparatory to a major piece of written work for example)? This would allow lecturers to assess students' arguments prior to submission, help students to refine their critical thinking skills, and assist students in producing better, well-argued written work. Given the documented advantages of argument mapping, and the apparent failure of tertiary institutions to impart critical thinking skills, it seems to be an appropriate course of action for educational institutions in the twenty-first century.

REFERENCES

Annis, D., & Annis, L. (1979). Does Philosophy Improve Critical Thinking? *Teaching Philosophy, 3*, 145-152.

Arum, R., & Roksa, J. (2011). *Academically adrift: Limited learning on college campuses*. Chigago, IL: University of Chicago Press.

Carrington, M., Chen, R., Davies, M., Kaur, J., & Neville, B. (2011). Enhancing Critical Thinking: The Effectiveness of a Single Intervention of Computer-Aided Argument Mapping in a Marketing and a Financial Accounting Subject. *Higher Education Research and Development, 30*(3), 387-402.

Davies, M. (2011). Mind Mapping, Concept Mapping, Argument Mapping: What are the Differences and Do they Matter? *Higher Education, 62*(3), 279-301.

Dutton, D. (2011). The Bad Writing Contest: Press Releases, 1996-1998. from http://www.denisdutton.com/bad_writing.htm

Halpern, D. F. (2002). *Thought and Knowledge: An Introduction to Critical Thinking* (4th ed.): Lawrence Erlbaum Associates.

Harrell, M. (2011). Argument diagramming and critical thinking in introductory philosophy. *Higher Education Research and Development, 30*(3), 371-385.

Hitchcock, D. (2003). *The effectiveness of computer-assisted instruction in critical thinking*. Paper presented at the Informal Logic: Proceeding sof the Windsor Conference, Canada.

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

Kulhavy, R. W., Lee, J. B., & Caterino, L. C. (1985). Conjoint Retention of Maps and Related Discourse. *Contemporary Educational Psychology, 10*, 683-699.

Larson, A. A., Britt, M. A., & Kurby, C. A. (2009). Improving Students' Evaluation of Arguments. *The Journal of Experimental Education, 77*(4), 339-365.

Larson, M., Britt, M. A., & Larson, A. A. (2004). Disfluencies in Comprehending Argumentative Texts. *Reading Psychology, 25*(3), 205-224.

McMillan, J. (1987). Enhancing college students' critical thinking: A review of the studies. *Research in Higher Education, 26*, 3-29.
The Monash Critical Thinking Study. (2009). Retrieved 22/10/09, from http://arts.monash.edu.au/philosophy/research/thinking/04webmap.php

Paivio, A. (1983). The Empirical Case for Dual Coding. In J. Yuille (Ed.), *Imagery, Memory and Cognition*. Hillsdale, N. J.: Lawrence Erlbaum.

Pascarella, E. T. (1989). The development of critical thinking: Does college make a difference? . *Journal of College Student Development, 30*(1), 19-26.

Resnick, L. B. (1987). *Education and learning to think.* . Washington, DC: National Academy Press.

Schwartz, N. H. (1988). Cognitive processing characteristics of maps: Implications for instruction. *Educational and Psychological Research, 8*, 93-101.

Stenning, K., Cox, R., & Oberlander, J. (1985). Contrasting the cognitive effects of graphical and sentential logic teaching: Reasoning, representation and individual differences. *Language and Cognitive Processes, 10*, 333-354.

Twardy, C. (2004). Argument Maps Improve Critical Thinking. *Teaching Philosophy, 27*(2), 95-116.

van Gelder, T., Bissett, M., & Cumming, G. (2004). Enhancing Expertise in Informal Reasoning. *Canadian Journal of Experimental Psychology, 58*, 142-152.

Vekiri, I. (2002). What is the Value of Graphical Displays in Learning? *Educational Psychology Review, 14*(3), 261-312.

Walton, D. (2000). Problems and Useful techniques: My experiences in teaching courses in argumentation, informal logic and critical thinking. *Informal Logic, 20*(Teaching Supplement 2), 35-39.

Winn, W. (1991). Learning from Maps and Diagrams. *Educational Psychology Review, 3*(3), 211-247.

Martin Davies holds doctoral degrees in Philosophy from the Flinders University of South Australia and the University of Adelaide. He won the H. J. Allen Prize in Philosophy from the Unversity of Adelaide in 2002. He is an Associate Professor in Higher Education and an Honorary Research Fellow in Economics in the Faculty of Business and Economics at the University of Melbourne. He is a former editor of the A-ranked journal *Higher Education Research and Development*, and is an Associate of the argument mapping consulting company *Austhink.*