

Computer-Assisted Argument Mapping: A Rationale Approach

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Abstract: *Computer-Assisted Argument Mapping (CAAM) is a new way of understanding arguments. While still embryonic in its development and application, CAAM is being used increasingly as a training and development tool in the professions and government. Inroads are also being made in its application within education. CAAM claims to be helpful in an educational context, as a tool for students in responding to assessment tasks. However, to date there is little evidence from students that this is the case. This paper outlines the use of CAAM as an educational tool within an Economics and Commerce Faculty in a major Australian research university. Evaluation results are provided from students from a CAAM pilot within an upper-level Economics subject. Results indicate promising support for the use of CAAM and its potential for transferability within the disciplines. If shown to be valuable with further studies, CAAM could be included in capstone subjects, allowing computer technology to be utilised in the service of generic skill development.*

1. INTRODUCTION

This paper outlines the educational value of a software tool called *Rationale* (which supersedes an earlier product called *Reason!Able*) and the methodology of Computer-Aided Argument Mapping (hereafter, CAAM) in teaching critical thinking skills. Graduate attributes, such as critical thinking, have recently been called “wicked” attributes owing to their difficulty in being taught and assessed (Knight & Page, 2007). This paper suggests that critical thinking can be taught and assessed and investigates a methodology for doing so in the context of a Faculty assessment task embedded within a normal Faculty subject stream. While the study has limitations in terms of the amount of time allocated to the trial, the study clearly shows the potential of CAAM, and how it might be used in a more widespread fashion in many discipline areas and subjects.

CAAM claims to improve critical thinking by developing generic skills of reasoning and argumentation. Presently, CAAM is being used within the professions such as banking and law. But it is also used in the public sector; in particular, the military. The use of CAAM in education sector is less widespread. However, there have already been empirical studies demonstrating CAAM’s effectiveness in different discipline areas, and the resulting improvement of critical thinking abilities as measured by a standard critical thinking test.

This paper summarises the results of these studies and outlines a trial of CAAM within a particular subject in Economics (**Australian Economic History 316-214**) at a major research-intensive university. Unlike prior empirical studies, this paper attempts a qualitative analysis by looking at the views of students as expressed in comments to an evaluation questionnaire. The paper provides another reason to take CAAM seriously. The literature suggests that there are substantive gains in critical thinking ability from the use of CAAM. If students indicate that they have benefited from its integration into the curriculum, this is an additional source of valuable data. If student comments

about CAAM are positive, there are good grounds to consider the widespread roll-out of CAAM as a teaching and learning tool.

2. THE IMPORTANCE OF CRITICAL THINKING

Critical thinking is an essential skill for the reflective citizen as well as the student (Ennis, 1985, 1990). It is a skill that is increasingly sought by employers in the “knowledge” economy and is of economic and social importance. Surveys of employers in the business sector consistently show that a key skill demanded by employers is “critical thinking”. This skill is often ranked by employers as only marginally lower than “communication skills”, “academic qualifications” and “previous work experience” (“Graduate Outlook”, 2006). An employer survey found that “capacity for independent and critical thinking...sets apart successful from unsuccessful [job] applicants...but it is *rare*” (Commonwealth of Australia, 2000).

Most universities stress the acquisition of critical thinking skills as one of the key “graduate attributes”. They claim to foster critical thinking, however, this is usually done by indirect means; i.e., by means of absorption of subject content. Outside classes in informal logic—taught to a small proportion of the student population—critical thinking is not explicitly taught. This means a significant gap in terms of what employers want in graduates (the skill set they bring to the workplace), and the skills taught to graduates at university. If critical thinking skills are not explicitly taught, and if employers demand them, then this suggests that a re-alignment might be needed. The issue then becomes, how are critical thinking skills best taught?

3. TEACHING CRITICAL THINKING

There is debate in the academic literature as to the best way to teaching critical thinking. Some argue that it needs to be taught by means of “generic” skills infused into discipline subject-matter (Davies, 2006b; Ennis, 1997; Melville Jones, 1999); others argue that critical thinking requires only a specific disciplinary approach (without treating critical thinking as a generic skill) (McPeck, 1990, 1992). Learning subject content is, by itself, necessary and sufficient for learning critical thinking according to this latter view. The “generalist-specifist” debate remains unresolved with both sides mounting plausible arguments for their respective positions (Davies, 2006b; Moore, 2004; Quinn, 1994).

The key problem, however, is this. Students are supposed to develop critical-thinking skills during their undergraduate degree (Kuhn, 1991), yet demonstrably, most students do not think very critically. A recent review claimed that the average student completing an undergraduate education only gains an improvement of between 0.5 and 0.65 standard deviations (SD) using standard critical thinking assessment tests (Hitchcock, 2003). This is about 0.08 SD per semester on average. Much of this increase could merely be due to maturation (Halpern, 2002; McMillan, 1987; van Gelder, Bissett, & Cumming, 2004). It appears then, that the present situation—assuming that subject content alone will result in improved critical thinking skills (by means of immersion)—is not working as well as it should. Theorists working in the area claim that the existing approaches to improving critical thinking—using discipline-specific models in the hope that students will learn critical thinking—are inadequate, and that a new approach is needed (Walton, 2000).

Some educators have promoted a shift from rote (*reproductive*) learning to critical (*analytical*) learning, and finally, to innovative (*speculative*) learning (Ballard & Clanchy, 1988). It is assumed by most educators that this is something that a tertiary education will provide. It is assumed that the move from reproductive to analytical learning is being undertaken via the transmission of subject content. However, it is by no means certain that this happens. Lecturers rarely assess formal

argument structure, nor the progression rates (if any) in students' critical thinking skills by means of standard critical thinking assessment instruments (e.g., the California Critical Thinking Test). This is not entirely the fault of lecturing staff. There has been, until now, no reliable means of assessing students' understanding of arguments, and their ability to construct and critique arguments. It will be argued that CAAM finally gives academic staff that ability.

4. WHAT IS CAAM?

CAAM, a recent innovation, works in a manner similar to standard geographical and topographical maps. Describing how to reach a certain destination is less effective than drawing a simple map. This is why we use maps. Maps provide all the necessary informational content in a more digestible manner. It is often said that "pictures tell a thousand words". It is also true that prose is more subtle than pictures (van Gelder, 2007). CAAM combines the advantages of prose and structured pictorial representation.

There is empirical evidence that CAAM improves critical thinking skills. In a recent project on CAAM-based critical-thinking education using a test and post-test procedure and a standard critical thinking measurement tool, CAAM repeatedly produced gains in students' critical thinking (van Gelder et al., 2004). These gains amounted to 0.8 SD in 12 weeks (Twardy, 2004; van Gelder et al., 2004). This is roughly equivalent to a shift from the 50th to the 79th percentile. On average one-semester, one-subject CAAM-based interventions achieved roughly seven to eight times the average gain from a normal semester. This is comparable to gains achieved in an entire 4-year US undergraduate degree. Similar results have been found by others (Donohue, van Gelder, Cumming, & Bissett, 2002; Harrell, 2005; Hitchcock, 2003; Solon, 2001, 2003). The following section outlines the theoretical and conceptual rationale for a CAAM.

5. CONCEPTUAL FRAMEWORK OF CAAM

The CAAM methodology rests on the following assumptions about teaching "critical thinking" (This framework is further described in van Gelder *et al* (2004)):

- Critical thinking is a complex set of general, transferable, cognitive skills;
- Critical thinking skills are like other skills (e.g., tennis playing, windsurfing), in so far as they require dedicated practice;
- *Expertise* in these skills can be acquired, like expertise in any other skill (Ericsson & Charness, 1994; Ericsson & Lehmann, 1996; van Lehn, 1996);
- Structured diagrams incorporating prose are able to represent arguments better than traditional discursive prose on its own.

Rationale, the software, is said to represent arguments better than discursive prose for the following reasons (van Gelder, 2007).

- *Usability*: Software designed for argument mapping is said to augment the human brain's ability to understand and present reasoning (see **Section 6** below). It provides a more *usable* way of improving critical thinking skills, just as tools in other areas help the development of other skills. A fountain pen, and a ball-point pen, both aid in the skill of writing; so does a word processor. The word processor improves on earlier writing tools by being more usable. Similarly, a beginner's windsurfing board provides a more usable way of improving windsurfing skills (by being larger and more stable). The traditional manner of presenting and criticising arguments is, of course, in prose. It is claimed that CAAM is more usable than prose in improving skills in critical thinking.
- *Complementation*: It is claimed that CAAM also improves the human brain's ability to process information. It does this by *complementing* what the human brain can already do

(albeit imperfectly). As we shall see below, our memory stores are limited, as is our ability to “chunk” complex pieces of relevant information and sift them from irrelevant information, a necessary skill in argumentation. CAAM allows computer technology to be utilised in the service of generic skill development.

- *Semi-formality*: It is claimed that CAAM provides a usable, complementary tool for *semi-formal* reasoning. Human beings typically reason very informally with the imprecise instrument of human language. By contrast, other languages are very formal in nature. Mathematics, programming languages, logical systems, are all governed by precise semantic rules and algorithms. Traditionally, critical thinking has been taught by means of teaching “formal” logical systems (predicate calculus, Aristotelian syllogisms, propositional logic). However, it is not clear that critical thinking skills improve in this way. CAAM provides a new method of teaching critical reasoning by merging the human mind’s natural informality with the more rigorous semi-formality of structured diagrams.

There are a number of argument mapping tools available. The tool used in this paper, *Rationale*, is available from <http://www.austhink.com>

6. CRITICAL THINKING AS A COGNITIVELY COMPLEX SKILL

Understanding an argument is a cognitively complex task. Students are often cognitively overwhelmed. Students from non-English speaking backgrounds (NESB)—an increasingly important cohort of students in western tertiary institutions around the world—find this kind of task especially complex. At the Faculty of Economics and Commerce at the University of Melbourne, for example, international students account for around 60 percent of the postgraduate cohort, and the number is growing. These students constantly say that “critical thinking” is one of the more difficult expectations placed upon them (Samuelowicz, 1987).

Why is understanding arguments so demanding? In addition to the complexities of distinguishing different parts of the argument, students must also deal with the complexities of academic language. The student must, in addition, be able to:

- (i) Succinctly paraphrase claims;
- (ii) Distinguish premises from conclusions;
- (iii) Locate crucial hidden premises;
- (iv) Put the claims into the appropriate logical order;
- (v) Show the inferential link(s) from premises to conclusions.

Working with complex academic material this is hard enough even for native speakers of English; it is an exceptionally difficult task for international students. CAAM allows the parts of an argument to be laid out, and built up, in a clear, structured diagram. This is said to reduce cognitive load considerably and promote understanding (van Gelder, 2005).

“Cognitive load” refers to the extent to which a task demands cognitive resources. To appreciate the importance of this concept, compare the usual three-by-three “noughts and crosses” game with a four-by-four or five-by-five variation of the same, and the notion of cognitive load will be immediately clear (if the games are played). Which game involves more cognitive work? As a variation, imagine playing a conventional three-by-three game without putting marks on paper, and instead by taking it in turns to *verbalise* the moves to one’s opponent. Why is this much harder? It is more difficult because more demands are being placed on memory. We become cognitively overloaded (van Gelder, 2007). Humans are very limited in terms of our storage of information in short term memory. The phenomenon of “7 plus/minus 2” items being an optimum amount human memory recall, if “chunked”, is an instance of appropriate cognitive load (Miller, 1956). However,

in recent studies even his much discussed figure has been revised down to 4 (Cowan, 2000). Memory is clearly unreliable and imperfect guide when processing complex information.

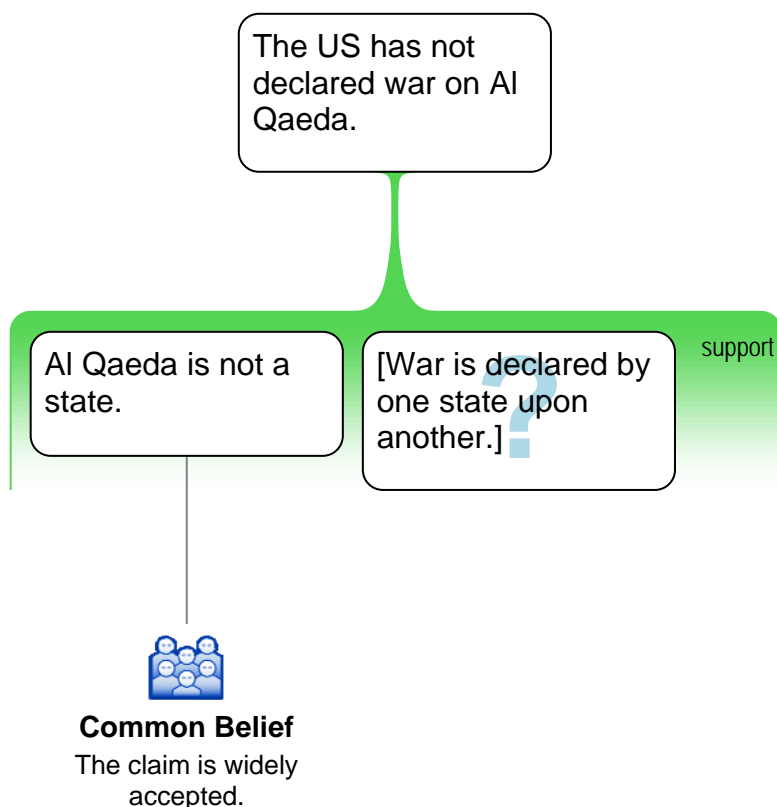
We become especially cognitively overloaded when dealing with arguments. Arguments are constructed in words and sentences and (importantly) the inferential links being made between the sentences. Processing all this puts even more cognitive load on our short-term memories. Take the following, rather artificially complex, example (based on a logic puzzle by Lewis Carroll):

Since the only animals in this house are cats, and no cat fails to kill mice, all animals in this house kill mice. Now, given that none but carnivores kill mice, it's clear that all animals in this house are carnivores. Of course, no animals are carnivorous unless they prowl at night. So, all animals in this house prowl at night (Jefferies, 2007, "Lewis Carroll Puzzles", 2007).

It takes quite a bit of intellectual work, and several readings, to understand the chain of reasoning being made here even though the conclusion might be easy enough to find. This is so despite the simple words and ideas being used. We shall return to this example in a moment. The problem of understanding reasoning is compounded in the case of academic arguments which use longer, more complex sentences, technical terms, assumed and tacit premises, and sometimes inadequate or inexplicit links between the premises.

6.1 Simple Arguments

The argument: *Al Qaeda is not a state, so the US has not declared war on it* (something one might see in a "Letter to the Editor" looks deceptively like an assertion or claim, rather than an argument. The argument is plotted using the *Rationale* software below. It clearly shows the argument as premises leading to a desired conclusion. The argument is plotted below, using the software, in easy-to-follow flowchart format. Premises are represented in boxes and the conclusion is shown at the top of the flowchart.



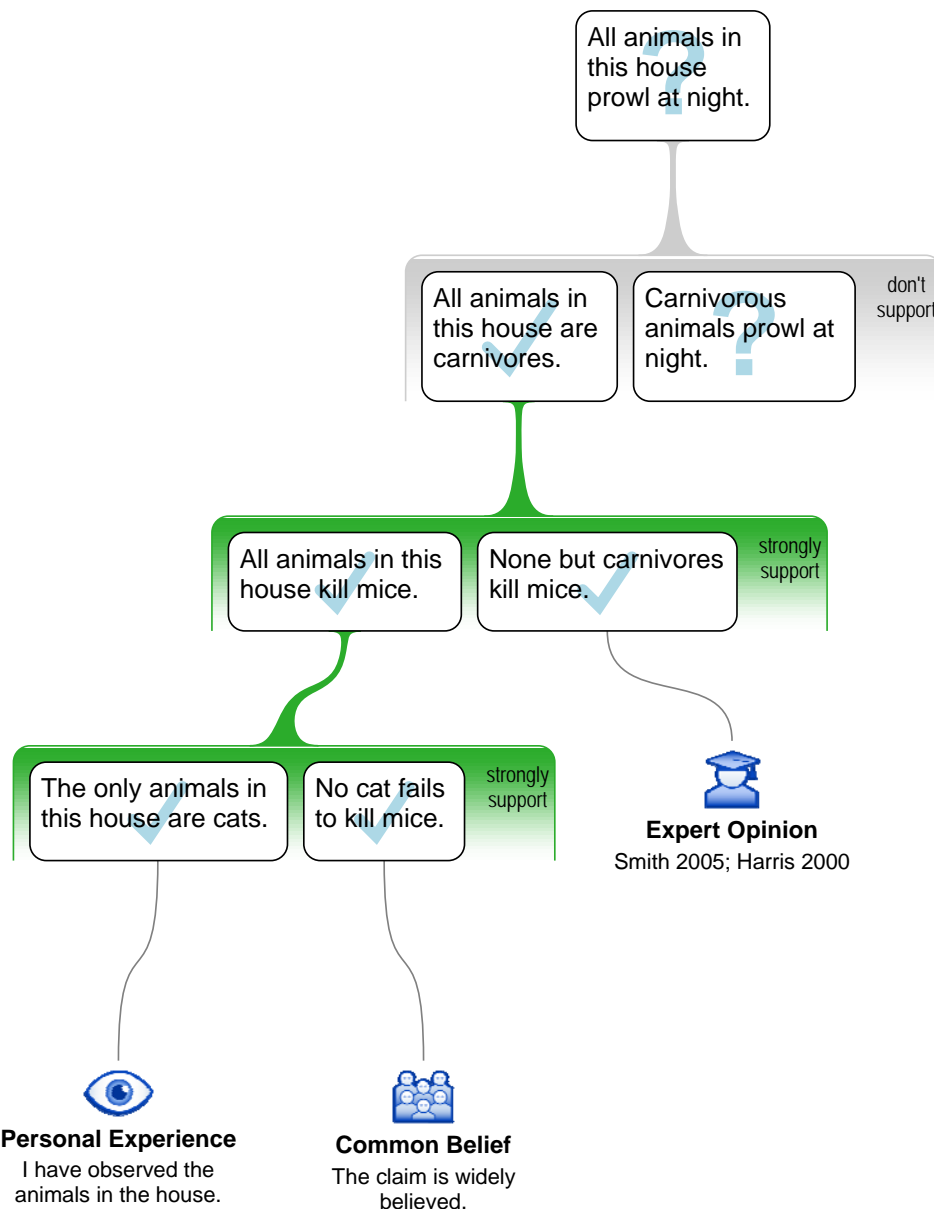
Implied premises are shown in [...]. Together the premises constitute the *reason* for the desired conclusion (which is supported, even though it only rests on "commonly-held beliefs" as opposed to

“expert opinion”, “definition” or “statistical evidence” or other more compelling grounds). “Ticks” and “question marks” indicate levels of premise plausibility in CAAM. Quite complex arguments can be represented in this format.

The above example is simple. It does not reflect the cognitive load that students typically experience with authentic, germane academic texts. The dense academic prose students encounter during their studies only magnifies the problems associated with cognitive overload. This raises significant problems for most students. Many international students have particular trouble grasping arguments when it is presented in complex prose. They often resort to memorisation of information required, not understanding (i.e., “surface”, not “deep” learning) (Biggs, 1987; Entwistle, 1981; Marton & Saljo, 1976a, 1976b; Ramsden, 1992). However, when arguments are visually mapped, students might develop a clearer understanding, and learning might thereby be enhanced.

6.2 Complex Arguments

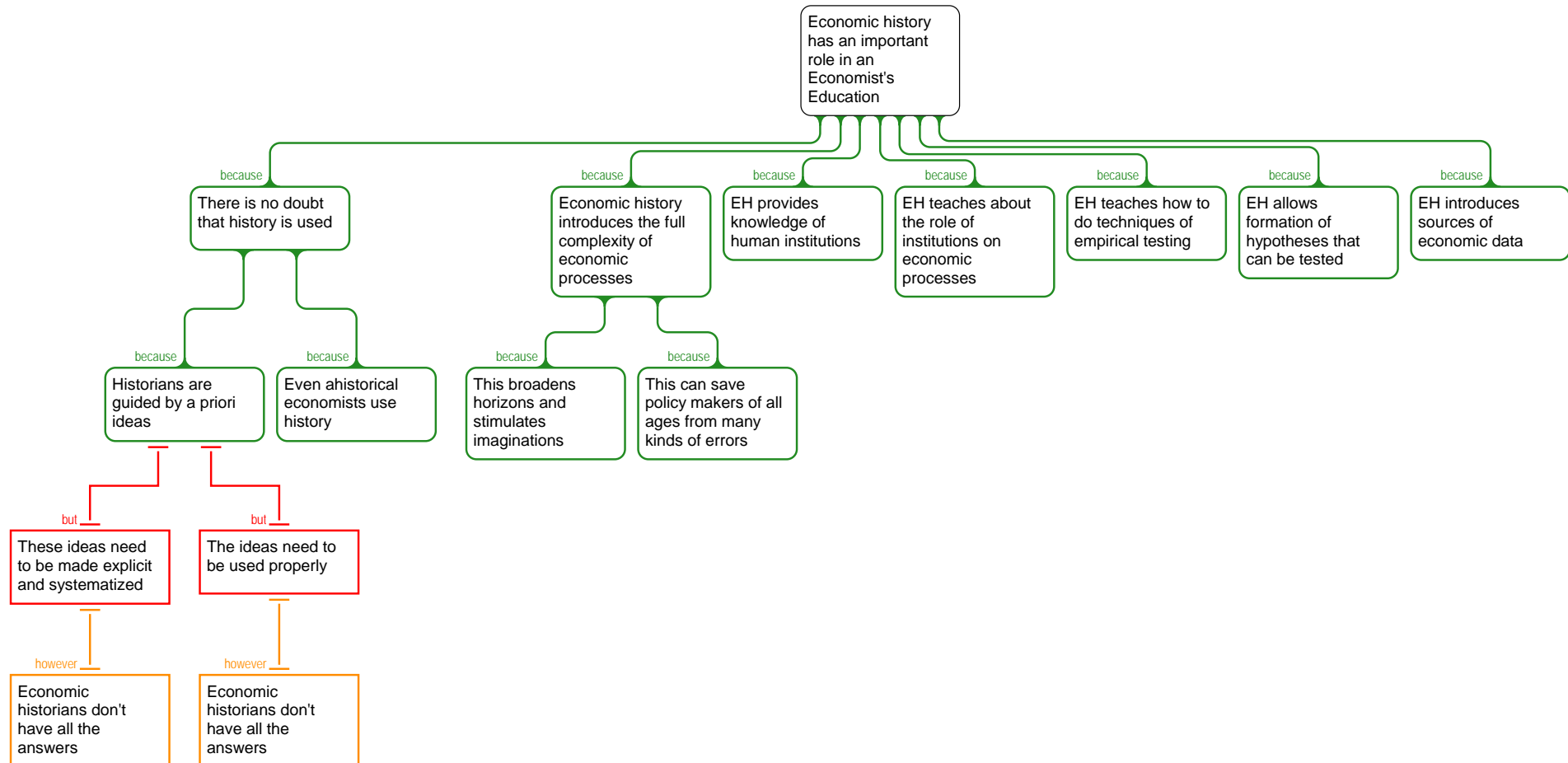
Returning to our Lewis Carroll example, the following argument map indicates the logical connections between the claims made. The argument map is easier to process than the prose version given earlier. (Note that, like the previous example argument, a “basis” or ground is given at the terminal points of the argument, and these are weighted in terms of plausibility. This allows for the accuracy of conclusion of the argument to be determined.)



Of course, in academic writing there are passages of text which are vastly more complex than this. There is often considerable amount of “chaff” amongst the kernels of “wheat”. The CAAM approach enables readers of academic writing to focus on the following questions: What is the main argument being made? What is the conclusion of the argument? How does the author reach his conclusion (on what premises is the conclusion based)? Dense passages of prose require several readings—and some serious thinking—in order for the main argument to become transparent. To make the task more complex the central point being argued for in some academic arguments is tacit (not explicitly stated). The CAAM approach forces clarity on these issues. The argument, and reasons for the argument, become much clearer when “mapped”. An argument map representing a sustained and complex academic argument over four pages for the contention: *Economic history has an important role in an economist’s education* is presented below. (Due to reasons of space we cannot present the source material.)

Sample Argument Map

The following example was discussed in the trial described in **Section 9** of this paper (from Cameron, 1965).



7. USING CAAM TO HELP STUDENTS FROM NESB BACKGROUNDS

At the University of Melbourne, like elsewhere, NESB students are generally smart, dedicated and hardworking. Their English is adequate and often excellent—admission requires an IELTS score of at least 6.5. Yet, because their education often emphasized rote learning, many have considerable difficulty understanding how to critique articles or argument (Samuelowicz, 1987). Argument mapping is one way in which to teach critical thinking to such students. Of course, argument mapping is not easy, even for experienced academics, and training and practice is needed. It is envisaged that argument mapping might eventually be incorporated as a skill in graduate education or in interdisciplinary “capstone subjects”.

There are other reasons why CAAM might assist such students. Recent empirical studies have detected subtle, yet systemic intercultural differences in reasoning patterns between Asians and Westerners, differences that are not explained by language effects (Ji, Zhang, & Nisbett, 2004). These intercultural difference might not be large enough to result in vast and appreciable differences in thinking patterns or behaviour as a result of such thinking patterns, but they are important for any aim to teach critical thinking. For example, there are differences in the use of what are called “superordinate categories” to guide reasoning (Asians will tend to be guided by them, Westerners will not); the use of plausibility of conclusions in decisions about logical validity (Asians, and not westerners, will be tend to be influenced by plausible conclusion in how they judge arguments—regardless of argument validity); and the use of memorisation techniques in preference to rules of reasoning (Asians will be more likely to memorise information when given diagrammatic reasoning simulacrum as opposed to adopting tacit logical rules). For reasons of space I cannot detail the differences here. For a summary of this research, see (Davies, 2006a; Nisbett, 2003).

CAAM might, if adopted more widely in the curriculum, be able to ascertain the extent of such differences in reasoning patterns. However, the present paper is not directed to that aim. It aims to simply determine students’ perceptions of the value of argument mapping as a teaching tool.

8. THE STUDY

CAAM was trialled in the Faculty as a teaching tool for students in the subject **Australian Economic History (316-214)** for a specific assessment task (described below). The class consisted of 42 students in three separate tutorial groups. The content taught for this task was a normal part of the core curriculum of the subject, although the manner in which understanding was evaluated was supplemented by a class on argument mapping. The procedure used is described below.

1. The Coordinator of the class told students in the lecture that, during the week, they would receive a tutorial class on argument mapping. They were given a short article to read on the role of economic history to an economist’s education as pre-reading (Cameron, 1965).
2. A single one-hour class on the CAAM methodology was given during normal class hours to a group of 42 students. During this class, the nature of argument mapping was outlined, and then a number of simple examples were given. Several simple maps were discussed leading to more complex maps similar to the examples given earlier. A very complex argument for the proposition: *JFK was killed by a conspiracy* was briefly mentioned.
3. The short article by Cameron given to students as preparatory reading was then introduced. An argument map was begun by the instructor but not completed. Students were given time to complete their map of the Cameron article (which had been read before attending the class) in groups of two or three. Resulting argument maps were discussed in class.
4. Students were then given a copy of a longer, more complex article by Ged Martin, entitled “Economic Motives for the Founding of Botany Bay” (Martin, 1976). They were then asked to complete a more complex assessment task for homework. The coordinator of the subject

required all students completing the subject to complete an argument map for assessment (10 percent of the semester mark). Students were required to “map” an argument (or a “branch” of the argument) from the Ged Martin’s article.

5. Within a two week period, all assessment tasks were handed in and marked out of a total grade of 10 by the course coordinator.
6. Final grades given for all students were as follows:

Score	Number students
9 or higher	18
8.5	11
8	7
7.5	7
7	4
6.5	1
6	1

9. DISCUSSION AND LIMITATIONS

Appendix 1 provides student evaluation results from the pilot session on a Likert scale out of 5 for a variety of statements concerning: 1) presenter effectiveness, 2) content of presentation 3) the assessment task. Note that not all students who completed the assessment task completed the survey.

Appendix 2 provides a Data Display Matrix of student comments on the trial clustered in four categories: 1) The presentation, 2) the argument mapping software tool, 3) the argument mapping method, and 4) The assessment task. These comments can be summarised as follows.

The Presentation		The AM software		The AM Method		The Assessment Task	
Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
7	22	2	2	19	4	2	2

The Coordinator of the subject was “very pleased” with the students’ work and high average grades were awarded (see table above). Moreover, the students also benefited. A notable result was that students gave an evaluation rating of 4.29/5 for the question: *The material presented on AM enhanced my understanding of the assessment task.* (SD 0.642024). This seems to a clear view that the exercise was perceived to be helpful. Scores given for the assessment task clearly indicates solid understanding. However, several limitations should be noted about the trial.

The most serious limitation of the pilot study was the amount of time given to explaining and practicing critical thinking in class. One hour was clearly inadequate. This is reflected in the poor score for the statement: *The length of the session provided sufficient time to cover key areas* (3.41, SD: 0.885094). Most of the comments from students clearly outline dissatisfaction with the time allocated.

Some of the statements in the evaluation survey were also ambiguous and greater care should have been taken to phrase the statement. For example, *I had difficulties in completing the AM assessment task due to lack of knowledge of argument mapping.* It is not clear from this whether the responses were indicating: a) their problems were a result of lack of knowledge about AM; or c) their problems were due to some other unstated factor. Poor phrasing may explain the low result for this statement (2.10, SD: 1.113662).

Despite these limitations, there were a number of very positive responses. In response to the question: *What did you like most about the workshop?*, a number of responses were received (see

Appendix 2: Data Display Matrix). They indicate a widespread view that argument mapping was a worthwhile new skill. However, the comments obtained indicate that more time needed to be spent on presenting the argument mapping material.

It is clear from this small trial that students enjoyed CAAM and felt that it helped them in understanding the assessment task (4.29, SD: 0.642024). To a lesser degree, students felt that CAAM helped them: 1) understand the nature of arguments and critical thinking (3.95, SD: 0.986553); 2) helped them summarise academic articles (3.98, SD: 0.757885); 3) helped them to analyse academic arguments (3.95, SD: 0.804712), and 4) helped them determine problems with academic arguments (4.00, SD: 0.806226). Additionally, students felt that CAAM would be useful in other Economics subjects (3.78, 0.946993) and should definitely be applied in other Economics subjects (3.45, SD: 0.932325). These results are, of course, student perceptions, so no firm conclusions can be drawn. But if repeated in other contexts, they might indicate a general trend. The same trial was conducted with the same Economics class in the following year (2007) and very similar results were obtained. This indicates that the 2006 results were not an aberration. What can be taken from this is that CAAM is worth considering as additional tool to be used in teaching and learning and evaluation and assessment.

Finally, it should be noted the positive effect of the trial on students' learning behaviour. There was no time in the one-hour class to teach students how to use the CAAM software, yet despite this, subsequently around a third of the students voluntarily used it. They were not required to use the software for the assessment task, merely to draw an argument map (which they were told they could do on paper). Neither were they required to seek additional advice from the instructor as to how to map arguments or how to use the CAAM software. They appeared to be confident, enthusiastic and willing to learn for themselves. This is no small thing in an era of mass education and learning principally for the aim of employment. Putting in the time to learn the software is an indication they were genuinely interested in the CAAM methodology.

10. IMPLICATIONS

A number of issues arise as a consequence of the trial. These are raised here for further consideration.

Can critical thinking be assessed?

It is easy to give an impressionistic sense of understanding a topic when writing an assignment in prose. Time-pressed lecturers cannot read for "understanding" as often as they should (especially when required to mark a large number of assignments), and—as already mentioned—prose is much harder to cognitively process and retain in short-term memory. Demonstrating an understanding of a topic is made more challenging if one has to construct an argument map. It is easier to give an impressionistic sense of understanding in words. Argument maps are harder to "fudge", and students can get them clearly wrong. They are also simpler and quicker to grade. Moreover, argument maps require students to demonstrate their understanding of the basis for the assumptions made in an argument (and therefore their ability to critique them). Checklists can be devised to measure the key points given in an argument map, their inferential links, and their grounds. Points can be allocated accordingly. Though this does not exist presently, it is not hard to imagine fully computer-based assessment of argument maps where student work is instantaneously compared to an idealised template provided by the lecturer (within degrees of freedom). I am not suggesting that argument maps replace traditional forms of assessment, but be an additional assessment tool. It may be that CAAM finally provides a more independent way to assess "critical thinking" beyond the subjective impressions of a lecturer.

Can CAAM be transferred to other disciplinary contexts?

Since all disciplines require—either explicitly or implicitly—the use of arguments and inferences

from premises to conclusions, all disciplines can potentially use CAAM. Argument mapping can be integrated where “concept” or “mind” mapping techniques are already being used in subjects such as Accounting and Finance (Biktimirov & Nilson, 2006; Simon, 2007; van der Laan & Dean, 2007, forthcoming). Work is being done on ways of integrating concept mapping and argument mapping. It remains to be seen whether the CAAM methodology will be adopted, but as it is already being used in the professional context, the Law, Banking and Military (van Gelder, 2007), there is no reason to believe that it cannot be profitably used in Education. If the results from this trial are to be taken as representative of student views, it is probably time to consider trials in other disciplines.

11. CONCLUSION

This paper has outlined a trial of the CAAM methodology within the discipline of Economics. If student comments and ratings are any guide, the methodology appeared to be successful and worth developing. However, this needs to be qualified. It is important to provide sufficient time in the curriculum to present and practice the material; one hour allocated in the trial was clearly inadequate. On the positive side, students reported that their understanding of the assessment task improved as a result of using CAAM, and it appeared that they generally enjoyed the experience.

CAAM was not trialled as a way of improving critical thinking skills. It was naturally hoped that, as a result of the introduction of CAAM, students might enhance their reasoning skills by using argument mapping to assist in understanding the subject material in question. However, whether or not students’ reasoning skills actually improved was not tested. This would be the subject of another study. Future research might aim to establish the extent of improvement (if any) that follows from CAAM intervention within the disciplines. A study using the same subject content and involving control groups which did not use CAAM intervention would be necessary. This was not possible during the present trial. However, this is also something future research in this area might consider.

It would also be of interest whether the tool can be exported to other subjects that require understanding of complex arguments expressed in prose (e.g., in Management, Finance and Accounting) or, indeed, subjects outside the domain of Economics and Commerce entirely (e.g., the Sciences, Medicine, Law or Engineering). It is not hard to see how CAAM can be a very effective learning and teaching tool. Students can use this diagrammatic technique to demonstrate an understanding of arguments in various disciplines in addition—or perhaps in preparation for—writing assignments. If students can correctly “map” an argument, it could be said that they genuinely *understand* it. CAAM also promises a way for students from non-English speaking backgrounds to demonstrate their understanding of subject matter, with less reliance on complex English prose, the use of which disadvantages them.

Given the support outlined for its effectiveness, and the positive views of students for its use presented in this paper, CAAM has a promising future. CAAM can be a useful adjunct to academic staff as a teaching and learning tool, as well as an additional means of assessment.

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References

- Ballard, B., & Clanchy, J. (1988). *Studying in Australia*: Longman Cheshire.
- Biggs, J. (1987). *Student Approaches to Learning and Studying*. Hawthorn, Vic: Australian Council for Educational Research (ACER).
- Biktimirov, E. N., & Nilson, L. B. (2006). Show Them the Money: Using Mind Mapping in the Introductory Finance Course. *Journal of Financial Education*, 32(Fall), 72-86.
- Cameron, R. (1965). Has Economic History a Role in an Economist's Education? *The American Economic Review*, 55(1/2), 112-115.
- Commonwealth of Australia. (2000). *Employer Satisfaction With Graduate Skills*. ACT: Department of Education, Training and Youth Affairs (DETYA).
- Cowan, N. (2000). The Magical Number Four in Short-Term Memory: A Reconsideration of Mental Storage Capacity. *Behavioral and Brain Sciences*, 24, 87-185.
- Davies, W. M. (2006a). Cognitive Contours: Recent Work on Cross-Cultural Psychology and its Relevance for Education. *Studies in Philosophy and Education*, 26(1), 13-42.
- Davies, W. M. (2006b). An "Infusion" Approach to Critical Thinking: Moore on the Critical Thinking Debate. *Higher Education Research and Development*, 25(2), 179-194.
- Donohue, A., van Gelder, T., Cumming, G., & Bissett, M. (2002). *Reason! Project Studies 1999-2002*. Melbourne: The University of Melbourne.
- Ennis, R. H. (1985). Critical Thinking and the Curriculum. *National Forum*, 65, 28-31.
- Ennis, R. H. (1990). The rationality of rationality: why think critically? In R. Page (Ed.), *Philosophy of Education 1989* (pp. 402-405). Bloomington, Ill.: Philosophy of Education Society.
- Ennis, R. H. (1997). Incorporating critical thinking in the curriculum: An introduction to some basic issues. *Inquiry*, 16(3), 1-19.
- Entwistle, N. (1981). *Styles of Learning and Teaching; an integrated outline of educational psychology for students, teachers and lecturers*. Chichester: John Wiley.
- Ericsson, K. A., & Charness, N. (1994). Expert Performance. *American Psychologist*, 49, 725-747.
- Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: evidence of maximal adaptation to task constraints. *Annual Review of Psychology*, 47, 273-305.
- Graduate Outlook. (2006). *Graduate Careers Australia* Retrieved 12/10/07, from <http://www.graduatecareers.com.au/content/view/full/52>
- Halpern, D. F. (2002). *Thought and Knowledge: An Introduction to Critical Thinking* (4th ed.): Lawrence Erlbaum Associates.
- Harrell, M. (2005). *Using Argument Diagrams to Improve Critical Thinking Skills in 80-100 What Philosophy Is*. Pittsburgh, Pennsylvania: Carnegie Mellon University.
- Hitchcock, D. (2003). *The Effectiveness of Computer-Assisted Instruction in Critical Thinking*. Paper presented at the Informal Logic: Proceedings of the Windsor Conference, Canada.
- Jefferies, D. (2007). Maths and Language. *annteneX*, 118, 1-5.
- Ji, L.-J., Zhang, Z., & Nisbett, R. E. (2004). Is it Culture or Is it Language? Examination of Language Effects in Cross-Cultural Research on Categorisation. *Journal of Personality and Social Psychology*, 87(1), 57-65.
- Knight, P., & Page, A. (2007). The Assessment of "Wicked" Competencies: Report to the Practice-Based Learning Centre. Retrieved 5/6/07, from <http://kn.open.ac.uk/public/getfile.cfm?documentfileid=11063>
- Kuhn, D. (1991). *The Skills of Argument*. Cambridge: Cambridge University Press.
- Lewis Carroll Puzzles. (2007). Retrieved 12/10/2007, from <http://www.math.hawaii.edu/~hile/math100/logice.htm>
- Martin, G. (1976). Economic Motives for the Founding of Botany Bay. *Australian Economic History Review*, 16(2), 128-143.
- Marton, F., & Saljo, R. (1976a). On Qualitative Differences in Learning, I-Outcome and Process. *British Journal of Educational Psychology*, 46, 4-11.

- Marton, F., & Saljo, R. (1976b). On Qualitative Differences in Learning, II-Outcome as a Function of the Learner's Conception of the Task. *British Journal of Educational Psychology*, 46, 115-127.
- McMillan, J. (1987). Enhancing college student's critical thinking: A review of studies. *Research in Higher Education*, 26, 3-29.
- McPeck, J. (1990). *Teaching Critical Thinking: Dialogue and Dialectic*. New York: Routledge.
- McPeck, J. (1992). Thoughts on Subject Specificity. In S. Norris (Ed.), *The Generalizability of Critical Thinking: Multiple Perspectives on an Educational Ideal* (pp. 198-205). New York: Teachers College Press.
- Melville Jones, H. E. (1999, December). *Infusing Critical Thinking in Teaching Educational Theory*. Paper presented at the AARE-NZARE Conference, Melbourne.
- Miller, G. (1956). The Magical Number 7, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *Psychological Review*, 63, 81-97.
- Moore, T. (2004). The Critical Thinking Debate: How General are General Thinking Skills? *Higher Education Research and Development*, 23(1), 3-18.
- Nisbett, R. E. (2003). *The Geography of Thought: How Asians and Westerners Think Differently ... and Why*. New York: Free Press.
- Quinn, V. (1994). In Defence of Critical Thinking as a Subject: If McPeck is Wrong he is Wrong. *Journal of Philosophy of Education*, 28(1), 101-111.
- Ramsden, P. (1992). *Learning to Teach in Higher Education*. London: Routledge.
- Samuelowicz, K. (1987). Learning Problems of Overseas Students: Two Sides of a Story. *Higher Education Research and Development*, 6(2), 121-133.
- Simon, J. (2007). Concept Mapping in a Financial Accounting Course. *Accounting Education*, 16(3), 273-308.
- Solon, T. (2001). Improving critical thinking in an introductory psychology course. *Michigan Community College Journal*, 7(2), 73-80.
- Solon, T. (2003). Teaching critical thinking! The more, the better. *The Community College Experience*, 9(2), 25-38.
- Twardy, C. (2004). Argument Maps Improve Critical Thinking. *Teaching Philosophy*, 27(2), 95-116.
- van der Laan, S., & Dean, G. (2007, forthcoming). Assessment to Encourage Meaningful Learning in Groups: Concept Mapping. *Accounting Education*.
- van Gelder, T. (2005). Teaching Critical Thinking: Some Lessons from Cognitive Science. *College Teaching*, 53(1), 41-46.
- van Gelder, T. (2007). The Rationale for Rationale™. *Law, Probability and Risk*, 10.1093/lpr/mgm032.
- van Gelder, T., Bissett, M., & Cumming, G. (2004). Enhancing Expertise in Informal Reasoning. *Canadian Journal of Experimental Psychology*, 58, 142-152.
- van Lehn, K. (1996). Cognitive skill acquisition. *Annual Review of Psychology*, 47(513-39).
- 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.

Appendix 1: Student Evaluation Results from an Economics Trial

1: THE PRESENTATION (Presenter: Dr. Martin Davies)									
	Strongly Disagree				Strongly Agree	Response	Average	Total	SD
	1	2	3	4	5	Not Given			
Presenter Effectiveness									
1. The lecturer was well prepared and organised		1		20	21		4.45	42	0.632547
2. The subject was well-taught		1	4	25	12		4.14	42	0.6833
3. The lecturer communicated ideas and concepts clearly		1	11	16	14		4.02	42	0.840676
4. The material presented has the potential to help me in my future studies		4	9	20	9		3.81	42	0.890001
5. The presenter clearly answered my questions and concerns		1	16	9	11	5	3.81	42	1.227222
6. The presenter maintained interest		1	6	26	8	1	4.00	42	0.67082
Content									
7. The material on AM covered was practical and useful		2	10	18	12		3.95	42	0.85404
8. The range and depth of material on AM was adequate given the time available	1	3	7	21	10		3.86	42	0.9518
9. The pacing of the session on AM was appropriate for the content covered			12	19	11		3.98	42	0.748595
10. The length of the session provided sufficient time to cover key areas		7	15	16	4		3.41	42	0.885094

2: THE ACTIVITY AND ASSESSMENT TASK

	Strongly Disagree 1	2	3	4	Strongly Agree 5	Response Not Given	Average	Total	SD
11. The material presented on AM aided my understanding of the nature of arguments and critical thinking.		6	3	20	13		3.95	42	0.986553
12. The material presented on AM enhanced my understanding of the assessment task		1	1	24	15	1	4.29	42	0.642024
13. I believe that the AM methodology is useful in helping to <i>summarise</i> academic articles			12	18	11	1	3.98	42	0.757885
14. I believe that the AM methodology is useful in helping to <i>analyse</i> academic arguments		2	8	21	10	1	3.95	42	0.804712
15. I believe that the AM methodology is useful in determining <i>problems</i> with academic arguments		1	10	18	12	1	4.00	42	0.806226
16. I believe that the AM methodology would be <i>useful</i> in other Economics subjects		3	14	12	11	2	3.78	42	0.946993
17. I believe that the AM methodology should definitely be <i>applied</i> in other Economics classes		5	19	9	7	2	3.45	42	0.932325
18. I had difficulties in completing the AM assessment task <i>due to lack of knowledge of argument mapping.</i>	15	15	3	8		1	2.10	42	1.113662

Appendix 2: Data Display Matrix

The Presentation		The Software		The Argument Mapping Method		The Assessment Task	
Positives	Negatives	Positives	Negatives	Positives	Negatives	Positives	Negatives
I like how it started at basic and then got more complex	Presentation could be a little slower and examples discussed more thoroughly	[Software was] something different	Allow the software to be free to use for university students, we couldn't save, print or store the damn thing! Had to be done in one sitting. Very tedious capturing screens then inserting them into Word etc	The example of Intelligence analysis given (I'm personally very interested) & also the idea of a formal structure being given for analysis - the fact that it's independent of language is of great use in a multicultural area - I was very excited by the program's general educational potential	I couldn't really grasp the concept of how to draw the graphs or diagrams properly	The (software) program made the [assessment] process MUCH easier in practice	My lack of full understanding about AM. ... the initial claim could be a question or a statement or a broad issue (i.e. reasons for settlement of Botany Bay) or (settlement was for a penal colony). How to object and support objections and where they all should be put. [sic]
I liked that the presenter really started from the very basic ideas behind argument mapping, and then worked up to a complete example with a full text	I probably needed more than 1 tutorial to grasp the methodology better	explained what was needed - general principle behind it. Free software.	Instructions on how to actually connect it	Coming from an Engineering background, it offered a different methodology of analysis - something I was not prior aware of (or had much experience in)	Did not do the reading beforehand which made it difficult to construct argument map on the spot.	Spend more time going over the article everyone read so that students can practice with something more like the actual task.	More time spent as a group on analysing the Economic history article. I felt like we were thrown in the deep end going from small statements to a full article, which meant to move time to group

							argument mapping when doing assignment
Example argument mapping good prep for actual assessment exercise	A lot of material became quite rushed towards the end of the class			I think AM is a valuable skill, so liked having the opportunity to learn it more formally.	Whilst I find the idea of fragmented mapping to be a good one, I feel this kind of thing should be implied [sic] by second year university		
I liked how there were multiple examples so we could understand how to complete the task	A little too fast but that was understandable given the amount of stuff he was trying to get through			It was an interesting and useful concept that definitely deepened my understanding of the argument.	More in depth analysis on the example		
The workshop achieved its goal in my mind and doesn't need to be improved	Not long enough!			Provided a different way to analyse arguments [sic]			
I wouldn't change much. Just try and make the example reading/AM relatively harder, but not too hard to discourage students when it counts to their assessments [sic]	Probably that it was a little brief [sic].			Interesting concept, I liked seeing AM's for various issues, e.g. JFK assassination [sic]			
I thought it was about as good as it could be.	Felt a bit rushed as I guess we had a lot to get through			AM is an interesting idea			
	Would have liked a bit more time to			Understanding e.g. how an argument is			

	discuss the example article			comprised [sic]; i.e. reason, objection, strength, of argument, total persuasiveness			
	I felt like the workshop was a bit rushed at the end			The way it made me think about breaking down academic articles			
	An extra tute in that week needed			Introduced material and a technique I hadn't previously encountered at the uni			
	Less material or partly covered in a lecture to present rushing at the end [sic].			Made me visualise the key points of the article better.			
	Longer session, perhaps a smaller example for us all to start out on.			The concept of argument mapping is a great way to organise thoughts and make a logical argument			
	Definitely start with the basics, but maybe spend a little less time on them to ensure enough time to make it through the final slides.			The concept of argument mapping is a great way to organise thoughts and make a logical argument			
	have an interactive session where people can actually work through a			Ability to break down article into different areas of argument - help me			

	basic argument with the software			simplify a highly unclear and academically argued issue			
	Less material or partly covered in a lecture to prevent rushing at the end.			Helped me to better understand and read journal articles			
	Presenter [should have] show[ed] the rationale program			The emphasis on understanding texts			
	The slides needed to be longer on the page as it was difficult to read some of the example argument maps.			It was a good skill to acquire			
	Going through one easy example step by step may provide more background into how to go about completing an AM			It was something different - a change is always good. It was an interesting and new concept which is good, and a different way of going about things.			
	More practice beforehand			Wish I had known about the method earlier. Could be offered in earlier year subjects?			
	More time spent on a run-through of an actual argument						
	Not so many slides, that would be put 1/2 for 2 seconds because they						

	weren't they [incomplete comment]						
	Have it over 2 tutorials instead of one. It was a bit cramp and too much to take in one tute [sic]						