TEACHING CRITICAL THINKING WITH *RATIONALE*

Timo ter Berg[1], Eva van der Brugge[2]

[1]*Utrecht University of Applied Sciences (the Netherlands)*
[2]*University of Melbourne (Australia)*
timoterberg@kritischdenken.nl, evavd@student.unimelb.edu.au

Abstract

Although critical thinking is increasingly central in undergraduate education, most courses dedicated to improving students' critical thinking skills produce only slight results. Many students struggle to analyse arguments and fail to acquire transferable skills without dedicated practice. We present a method to teach critical thinking that has been shown to be very effective. This method emphasises deliberate practice of reasoning skills by argument mapping, a technique to visualise the underlying logical structure of argumentation. Empirical evidence suggests that practice with argument maps results in improved critical thinking, as measured by various standardised tests. This improvement is seen also in situations where students are not using argument maps. We present *Rationale*, software that has been developed to facilitate the implementation of this technique into teaching practice, and show how it has been used in classrooms internationally. Further, we present an innovative experimental course currently underway, which combines argument mapping with a number of innovative pedagogical techniques such as mastery learning, peer instruction and peer assessment.

Keywords: Critical Thinking, Higher Education, Generic Skills, Argumentation, Academic Writing, Reasoning, Software, Online Learning, Course Development, Mastery Learning

1 INTRODUCTION: CRITICAL THINKING IN THE UNIVERSITY CLASSROOM

While most higher education institutions agree that critical thinking is a central graduate outcome, few have a clear idea of how to teach it effectively. What is more, there is no consensus in scholarly research on how exactly to operationalise the concept. Far from another theoretical attempt at defining the idea of critical thinking, this paper presents an evidence-based approach to teaching critical thinking in the practice of the university classroom.

In this paper, we will stipulate critical thinking to be the active, skilful deployment of simple, general methods most conducive to truth or accuracy in judgment.. The relevance of this activity to academic reasoning and writing is clear. Currently, many institutions assume it suffices to teach these skills implicitly, embedded in field-specific courses. Others have dedicated critical thinking courses, often grounded in informal logic, but have given little thought to their effectiveness. It is now becoming clear that most undergraduates' reasoning skills do not improve much in the four years they spend at university [1]. This is unsurprising given the common methods of teaching critical thinking: critical thinking is combination of skills, dispositions, and knowledge, the integration of which requires a more active instruction method than a traditional course can provide.

1.1 Learning to think critically requires deliberate practice

In his overview of insights from cognitive science for improving the teaching of critical thinking, Van Gelder [2] compares learning critical thinking to ballet: it is a contrived activity. Humans are not naturally critical; we do not spontaneously question apparent patterns or stories. Furthermore, it is a higher-order skill, requiring the lower level skills it builds on to be mastered and combined in just the right way. As with any other higher-order skill, Van Gelder [2] concludes, "no fancy new technology or teaching technique is going to produce dramatic transformations without the necessary time and effort being applied" (p.42). The consequences of this insight to teaching critical thinking are summarised briefly here.

As Van Gelder [2] argues, given that critical thinking is a skill that requires practice, teachers need to move away from the traditional approach to teaching it. For critical thinking skills to improve, it is not enough to simply impart the theory of critical thinking or provide examples of good reasoning.

Students need to engage in deliberate practice, and this practice must be an explicit part of the curriculum. Theoretical instruction embedded in practice is helpful insofar as it provides students with the vocabulary to improve beyond basic levels. Furthermore, practice must include the art of transferring critical thinking skills from one situation to another – a challenge given the inherently general nature of these skills.

2 CRITICAL THINKING WITH ARGUMENT MAPS

The question of how to most effectively practice critical thinking skills in the classroom has not been studied systematically, that is, deliberate practice techniques have not been thoroughly compared in empirical settings. Many undergraduate instruction still consists mainly in imparting theory: for example long lists of fallacies and argumentation schemes. However, one approach to deliberate practice of critical thinking skills has garnered very promising results as compared to these traditional pedagogical strategies. This approach is based on argument mapping.

2.1.1 Argument mapping: visualising reasoning

Argument mapping is a way of visualising the relations of support in argumentative prose. As Fig.1 shows, argument mapping helps us organise and navigate complex information, it encourages us to clearly articulate our reasoning, and it allows us to communicate this reasoning quickly and effectively.

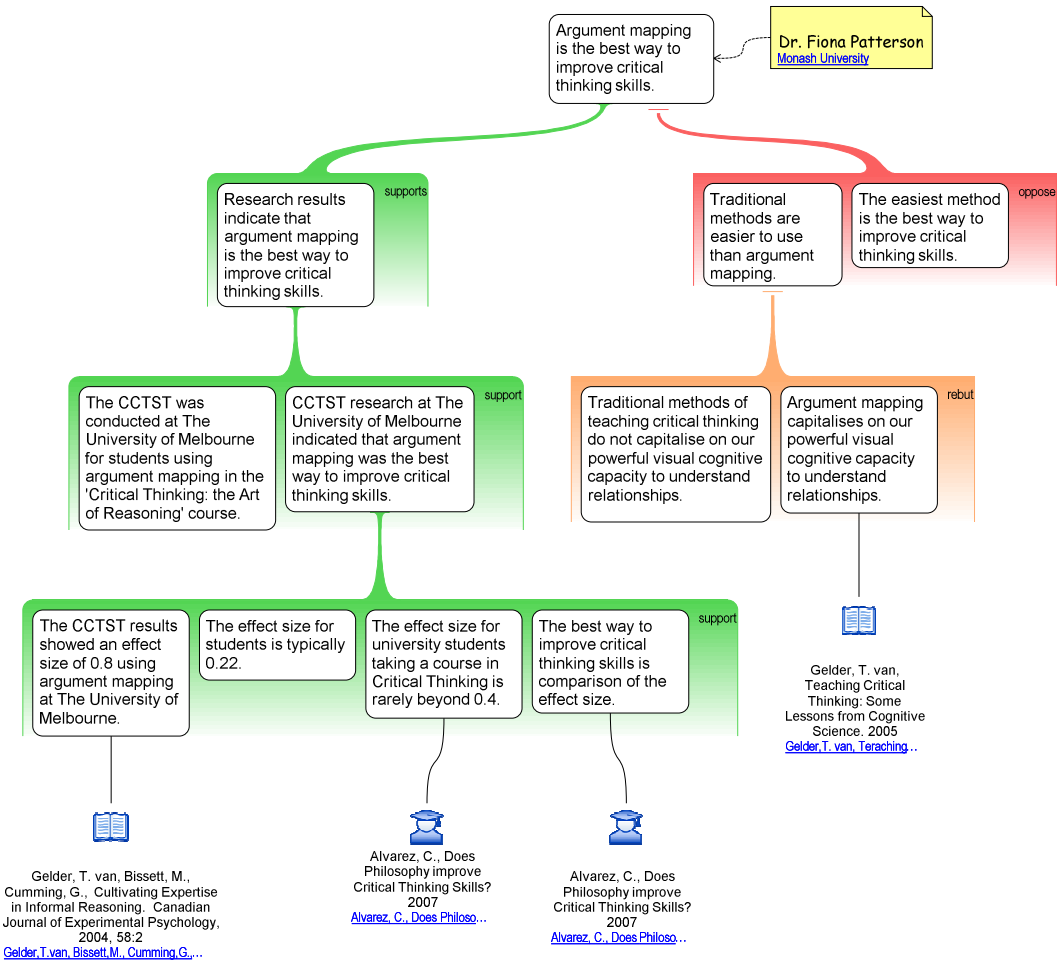

Fig. 1: Argument Map created in *Rationale*

The human mind simply cannot encompass at one time all aspects of a complex argument. The truth is that we can only ever focus on one or at most a handful of things at once. We generally focus on those few aspects of the argument that are particularly salient to us—often because they support our prior opinion—and neglect the rest. Mapping encourages us to express thoughts and their interrelationships much more precisely than we usually do, either when thinking alone or when debating with others. By stating claims simply and unambiguously, and by having to draw lines of inference between such claims, we understand the precise nature of the argument much better.

Argument mapping translates the abstract conceptual structure of reasoning into a simple spatial structure. A very large part of our brain is devoted to getting around in physical space—seeing where things are, and keeping track of our position in relation to things. An argument map taps into this vast reserve of processing power, bringing it to bear in understanding the conceptual layout of some complex issue.

2.1.2 Deliberate practice of critical thinking with Argument Maps

Argumentation is at the core of critical thinking, so handling arguments must be a central part of deliberate practice of critical thinking. Apart from providing an effective way to present reasoning, instruction in argument mapping lends itself particularly well to the teaching of critical thinking. As Davies [3] points out, empirical evidence tells us that processing information verbally as well as pictorially helps learning by avoiding cognitive overload.

Argument maps help students' to avoid getting bogged down in the convoluted prose of complex arguments and to identify problems in the reasoning within an argument. More importantly for teaching critical thinking, argument maps let the teacher see students' reasoning clearly laid out, allowing for vastly more effective and targeted feedback ([2], p. 45).

Since generic software does not facilitate structural revisions of argument trees---something crucial to effective practice---argument mapping is best practiced using specialised software. A number of dedicated argument mapping software packages are available. Here, we will discuss our research using the most popular and effective mapping tool from previous systematic research on the effects of argument mapping on critical thinking.

2.2 The effectiveness of argument mapping courses

Davies [2] gives an overview of empirical support for the effectiveness of argument mapping. Van Gelder has built up a convincing body of evidence over a period of five years to support the effectiveness of the course his team developed at the University of Melbourne. As measured on the California Critical Thinking Skills Test (CCTST), a twelve-week argument mapping course reliably improves critical thinking skills of undergraduates by around 0.8 standard deviations, similar to a shift from the 50th to the 79th percentile [4].

This is a very large improvement compared to the gains usually found in undergraduate education alone as well as those achieved with traditional critical thinking instruction. Hitchcock's 2003 review [5] concluded that in American universities the average student only gains about 0.08 SD per semester without instruction in critical thinking. Alvarez's recent meta-analysis of the effectiveness of standardly taught critical-thinking courses found that these produce roughly an average increase of 0.34 SD over controls [4].

Van Gelder's results have been replicated, notably in Twardy [6], where 90 per cent of Van Gelder's gains were found even after controlling for the teacher effect. Harrell [7] has found strong gains in critical thinking skills, although here effect sizes are not directly comparable since her reports are streamed by prior critical thinking ability.

Importantly, the pre- and post-tests used to measure these gains were standard critical-thinking tests. Since students did not make argument maps or have access to argument-mapping software while taking them, the results reflect how skills transfer to critical thinking tasks done without argument maps.

3 ARGUMENT MAPS IN THE CLASSROOM: RATIONALE

Van Gelder's results of deliberate practice in argument mapping, as well as our current research, are based on the software package Rationale, by Austhink software. Here we briefly discuss Rationale's

features, largely following Van Gelder's 2007 overview [7]. In short, Rationale allows users to visualise reasoning on any topic, by supporting rapid building, modifying, viewing, and sharing of argument diagrams.

3.1.1 Building argument maps

Reasoning involves navigating an often complex web of relationships between propositions. The most obvious way to visualise these relationships is by using "box and arrow" or "node and link" diagrams. Rationale helps users to easily produce these diagrams: claims, or premises, are created and combined into structures on an infinite two-dimensional workspace. The appearance of both boxes and arrows depend on their role in the argumentative structure.

3.1.2 Modifying and viewing argument maps

A refined idea of the full structure of a piece of argumentation usually grows during the building of a map. Once the reasoning is laid bare in a map, gaps and errors prompt reformulation and restructuring. Rationale supports easy modification of diagrams through drag-and-drop operations, as well as right-click menus, keyboard commands, and ribbon buttons. The basis of this functionality is automated layout of diagrams. Any time the user modifies the structure, for example, by relocating a box, the software automatically redraws the entire map, making Rationale distinctly functional as compared to other software.

With larger maps, it is often a challenge for users to scan the full context of reasoning in which a particular premise is situated, since even moderately complex maps are too large to fit on computer screens. Rationale facilitates easier viewing with panning and zooming, an overview window, and the automatic resizing of the map layout to focus on any particular map or part of a map.

3.1.3 Evaluating argument maps

To determine how strong arguments are by themselves and as a collective, Rationale provides evaluation overlays displayed on argument maps using icons, shading and colour. These overlays help to get a quick impression of patterns of strength in an argumentation structure.

Rationale provides a Reasoning mode, an Analysis mode, and an Evaluation mode. With the Essay-mode it is easy to transform an argument map in a well-structured essay.

Currently, a web-based version of Rationale is under development. In the mean time, a trial version of Rationale is available from the Austhink website. Rationale is licensed to a number of institutions in North America, Europe and Australia.

4 COMBINING ARGUMENT MAPPING WITH EVIDENCE-BASED INTERACTIVE TEACHING METHODS

If argument maps are so effective, why isn't everyone using them to teach critical thinking? Part of the answer may lie in the fact that argument mapping practice does not fit naturally into a traditional lecture format, and requires much time spent marking students' work. In earlier research, deliberate practice was ensured through workshop-style sessions in which students worked together in small groups on mapping exercises, while receiving immediate informal feedback from tutors. The increase of 0.7 SD that Alvarez [4] found for these courses is remarkably large for the tertiary education research literature. Still, there is good reason to believe that argument-mapping-based courses could be even more effective, if taught with mastery-learning techniques. This is the express aim of the Melbourne Critical Thinking project.

4.1 The Melbourne Critical Thinking project

The Melbourne Critical Thinking project aims to demonstrate that an argument mapping course can improve critical thinking skills by at least 1 standard deviation. This seedling project involved the development and implementation of an argument-mapping-based critical-thinking course taught using pedagogical techniques aimed at building on deliberate practice, individualised progression through

the material, and lots of timely and targeted feedback from both instructor and peers. These materials are available for free at www.improvingreasoning.com.

All teachers in the project are experienced, philosophically sophisticated teachers of critical thinking. As a part of this project, they took part in intensive Teacher Training Workshops. Instruction of this innovative course is taking place in 2013 for a considerable range of students: active intelligence analysts (RAF Molesworth and Canadian intelligence), intelligence analysts-in-training (James Madison University), midshipmen, many of whom will be active users of military and other intelligence, (US Naval Academy) and undergraduates with no intelligence affiliation (University of Melbourne, James Madison University).

Pre- and post-testing will be done on the Law School Aptitude Test (LSAT) logical reasoning questions. During these tests students will not have access to argument mapping software. Thus, the testing regime will give a good measure of the transfer from argument mapping-based learning to situations without argument mapping. Additionally, a varying set of secondary standardised tests will be administered in different institutions, among which are the CCTST and the Halpern Critical Thinking Assessment.

4.1.1 Mastery learning

The added effect of the Melbourne critical thinking courses is hypothesised to stem from Mastery Learning. In mastery-learning courses, students master the material in one section before progressing to the next, where they build on their newly acquired understanding. In mastery-learning courses, students are not working at "catching up", having to learn new material while still struggling with partially-mastered previous material. The practice activities and supporting theory in the course is divided into several modules; a student must pass each module at mastery level before moving to the next.

A student can take many online quizzes on the material in each module; there is no penalty for failing a quiz. There is immediate feedback on each quiz as well as explanations for why right answers are right and the wrong answers wrong. Students set their own pace and are guided by the detailed feedback, allowing them to focus on the material they find most difficult. In the version of Mastery Learning used in the Melbourne course, it is advisable but not strictly necessary that the students keep up with the lectures. Teachers act as facilitators who are available to provide guidance at whatever level the student is learning. The data gathered on these Mastery Learning quizzes can be used to determine precisely which topics students find particularly difficult.

The evidence for Mastery Learning effectiveness is long-standing. Kulik et al. [9] found that Mastery Learning produces an average one-semester gain of about 0.5 standard deviations more than standardly taught controls. Spencer's meta-analysis [10], which used slightly different criteria for study inclusion, found a gain of 0.7 standard deviations against standardly taught controls.

4.1.2 Timely, targeted peer feedback

A second evidence-based pedagogical pillar of the Melbourne critical thinking course is the delivery of targeted peer instruction and assessment. These peer-oriented techniques increase the amount of immediate feedback students receive, as well as students' engagement with the material.

A large part of each lecture is devoted to short small-group discussions of mapping problems, with students explaining their own answers to each other. These discussions are informed by textbook and homework assignments. During the discussions with their peers, many students change their minds about the optimal way to map argumentative structures. Remarkably, in previous research on this type of peer instruction in other fields students were roughly five-to-seven times more likely to shift from an incorrect to a correct answer than from a correct to an incorrect one, and learning outcomes are substantially improved ([11],[12],[13]).

Furthermore, students in the Melbourne course participate in peer assessment both informally in class, and in a more formal graded assignment. An assessment rubric is provided to help students structure their feedback on the quality of maps. An existing web-based peer assessment platform will be used to facilitate the random distribution of work to grade amongst students. Early empirical research indicates that peer assessment improves learning outcomes as well as student engagement and meta-cognitive skills [14].

5 CONCLUSION

Unlike traditional university courses, deliberate practice with argument mapping vastly improves students' critical thinking skills. Software tools and pedagogical methods for facilitating active instruction mean that the road to widespread uptake of these techniques is open.

REFERENCES

[1] Arum, R., & Roksa, J. (2010). Academically adrift: Limited learning on college campuses. University of Chicago Press.

[2] Gelder, T. V. (2005). Teaching critical thinking: Some lessons from cognitive science. College teaching, 53(1), 41-48.

[3] Davies, M. (2011). Computer-Aided Argument Mapping: An Educational Revolution?, in New Media, New Literacies, And New Forms Of Learning; Institute Of Education. London.

[4] Alvarez, C. M. (2007). Does philosophy improve critical thinking skills (Doctoral dissertation, Department of Philosophy, University of Melbourne).

[5] Hitchcock, D. (2003). The effectiveness of computer-assisted instruction in critical thinking. In J. A. Blair, D. Farr, H. V. Hansen, R. H. Johnson & C.W. Tindale (Eds.), Informal Logic at 25: Proceedings of the Windsor Conference. OSSA.

[6] Twardy C (2004) "Argument Maps Improve Critical Thinking" Teaching Philosophy, 27 (2):95-116

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

[8] van Gelder, T. (2007). Rationale: Making people smarter through argument mapping. Law, Probability and Risk.

[9] Kulik JA et al. (1990) "Effectiveness of Mastery Learning Programs: A Meta-Analysis" Review of Educational Research, 60 (2): 265-299

[10] Spencer, K. (1991). Modes, media and methods: The search for educational effectiveness. Brit. J. of Ed. Technology, 22, 12-22.

[11] Crouch et al (2007). "Peer Instruction: Engaging Students One-on-One, All at Once" Research-Based Reform of University Physics 1 (1): 1-55

[12] Guiliodori et al., (2009). "Student interaction characteristics during collaborative group testing" Advances in Physiological Education 33: 24-29

[13] Smith, M.K. (2009). Why Peer Discussion Improves Student Performance on In-Class Concept Questions Science 323, 5910 Pp 122-124

[14] Dochy, F. J. R. C., Segers, M., & Sluijsmans, D. (1999). The use of self-, peer and co-assessment in higher education: A review. Studies in Higher education, 24(3), 331-350.