Towards a Taxonomy for Argument Diagramming Tools

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Abstract: The technique of diagramming arguments has been first used in a didactic text by the logician Whatley in 1850, and later employed by modern theorists of argumentation as Wigmore, Toulmin and Beardsley, to build their model of argument analysis. In recent times argument diagramming revealed to be of valuable support in various learning tasks, from collaborative problem-solving to individual analyses of reasoning patterns. Many software applications have been developed to facilitate the visualization of reasoning structures. This paper presents a taxonomy to steer through them teachers and researchers working in different "ill-defined domains", in order to capitalize the opportunities they give.

Introduction

The present paper aims at building a taxonomy to classify tools for argument diagramming, in order to find one's bearing for different educational purposes. There are, in fact, a large number of software applications conceived to support learning through the visualization of argumentative processes taking place among students involved in collaborative tasks as problem-solving or deliberation, and students training to enhance their critical thinking skills. I introduce the issue with a reference to the revival of argumentation, which is taking place in a highly computerized society after a long period of disregard. I later mention two European educational projects which aim at enhancing argumentative reasoning.

Argumentation theory has an ancient tradition dating back to the Greek philosophers, but it has not been considered in the school curricula nor studied in the academic context since the end of the Roman Empire - one of the last authors being the philosopher Boethius (ca. 480–524 or 525). Argumentation had been relegated to the rank of *elocutio* – rhetoric –, in that its logical and dialectical components were ignored. Only recently, during the second half of the last century, was it brought forward again, due mainly to the efforts of Chaïm Perelman (1912–1984) and Stephen Toulmin (b. 1922).

As stated by Perelman and Olbrechts-Tyteca (1899–1987) in the fortunate *Treatise of Argumentation* (1958), one important reason can be found in the spread of the Cartesian paradigm, which counted as rational and therefore acceptable only the *more geometrico* reasoning, that is, exclusively, any necessary and apodictic knowledge grounded on solid evidence. Following Descarte's definition of reason, all probable or uncertain knowledge – the field of the "preferable" – was, as a consequence, excluded from scientific discourse. Together with other authors such as Wigmore and Toulmin, Perelman reintroduced argumentative reasoning into scientific debate as the method to obtain adhesion to non-self-evident and non-necessary knowledge, since: "*only the existence of an argumentation that is neither compelling nor arbitrary can give meaning to human freedom, a state in which a reasonable choice can be exercised*" (Perelman & Olbrechts-Tyteca 1969: 514). Argumentation – the "new rhetoric" – addresses all those fields which ask for a choice among alternative solutions depending on different values and belief systems: these kinds of fields are usually addressed in literature as "ill-defined domains", since they need solutions for "ill-structured problems" Among them are ethics, law, policy, philosophy and human sciences.

Argumentation has come up again in a highly-computerized context, the so-called "knowledge society", characterized by the capillary presence of digital technologies within every aspect of life, from school education to the workplace. The competitive advantage of the knowledge society doesn't consist in the digital technologies themselves, but rather in the great amount of information being produced and diffused, in the ability of people to elaborate it and in their creativity in using new technologies. To cope with the need to handle increasing amounts of information in a short time, a number of Decision Support Systems (DSS) have been implemented. DSS are a specific class of interactive software-based systems intended to support business and organizational decision-making activities, which represent highly-argumentative contexts. One of the most promising uses of DSS seems to be in the educational field where, in fact, many DSS-related software applications have been developed both to support the teaching and learning of argumentation itself (learning to argue) and to enhance learning in specific domains through argumentation (arguing to learn). Among them, two European projects are worth mentioning: DUNES and Argunaut.

DUNES - Dialogical argUmentative Negotiation Educational Software – involves nine partners among universities and educational institutions from eight countries. It aims at designing implementing and testing an environment for collaborative learning through discussion and argumentative interaction on the Web (http://www.dunes.gr/). It proposes many learning activities to scaffold collaborative learning within social interaction, in particular: a discussion space to model and support discussion among the participants, scenarios for collaborative learning and the related methods of intervention by the instructor, methodologies for evaluating activities. The discussion space is an interactive environment provided by a software called Digalo, which allows to build dynamic argumentative maps by rendering explicit and visualizing the main elements of an argumentation (i.e. claims, arguments, counterarguments) thanks to visual intuitive features like shapes and arrows, and thus to get a snapshot of the ongoing discussion. The studies undergone to test Digalo show that argumentation provides not only a strategic method to persuade about an opinion or to evaluate the "reasonableness" of a standpoint, but that it is also a powerful tool for learning.

Digalo is currently used also to implement the moderator interface in Argunaut, another European project which focuses on e-discussion. Argunaut intends to be an intelligent guide to support productive online dialogue in order to increase the effectiveness of the moderators' help and the quality of e-discussions (http://www.argunaut.org/). As for DUNES, this project considers both the technical aspects and the theoretical framework of the educational activities, thus it provides a computerized tool and develops associated pedagogical methodologies. Indeed, when a new technology enters an educational system, the whole system is influenced and every aspect has to be reconsidered (Cantoni & al. 2007).

In the next paragraph I will provide a definition of "ill-defined" domains, which are considered the proper space where argumentation takes place.

"Ill-structured domains" and "wicked" problems

Lynch et al. (2006), before presenting an overview of Intelligent Tutoring Systems (ITS) for ill-defined domains, have examined the existing definitions of the term and selected one as a working basis. Following their suggestion, I take into consideration the characteristics identified by Ashley and Pinkus (as cited in Lynch et al. 2006) and I integrate them with what the theorist Horst Rittel (1973) noticed about "wicked" problems as in contrast to "tame" problems. Ill-defined domains seem to have the following key characteristics: they cannot be easily defined; they have no clear goals or their goals can change during discussion; they can be approached in different ways according to personal beliefs, knowledge and level of abstraction; constraints are not readily apparent; instead, they have to be retrieved and examined during the solving process; solutions cannot be measured in terms of right or wrong but rather in terms of worse, acceptable or not acceptable; the ending point is somehow arbitrary, in the sense that a solution can be suitable for a problem but restrictive for another one of the same nature. Ill-structured problems can be hardly treated with a computer-based approach, even though computer simulations can offer some help. Just to have a realistic example, consider a pregnant woman who likes to know something about her baby before holding him/her in her arms: she would like to know if the baby is a male or a female, how tall he/she is, if his/her internal organs are growing well. She can get such information simply making an echography. Indeed, in the medical community there is a common agreement on using echography to have information about the fetus. Throughout an echography they can be relieved certain pieces of information but not others, and the constraints of such technology are known and stated. Questions concerning the baby's or the mother's physical wellness are termed "well-defined" or "tame" problems, in that they have been already studied and sufficiently understood. Tame problems share the following features: both their goals and the procedure to reach them are agreed by the members of the community of reference, constraints have been identified, explicitly stated and are the same for everyone dealing with the same problem; operators used to represent and solve them are frequently mathematical or logic-based; thus they can be treated following fixed rules or procedures, so that they allow a computer-based treatment.

Different would be the case if the same pregnant woman would ask herself about the best place where to give birth to her baby: at home, at the hospital, or in a specialized centre for underwater childbirth? There isn't any right or wrong answer, rather better or worse answers according to contextual elements, Weltanschauung, personal preferences.

Ill-structured problems, such as the better place where to give birth to a baby, cannot be solved through a deductive-formal model, since they ask for a choice among sustainable alternatives. As Perleman and Olbrechts-Tyteca stated, argumentation has to get the floor.

As discussed above, argumentation has come again to the attention in a highly computerized context, with which it has a relation of reciprocal influence. From one side, in fact, argumentation is an object of study for computer scientists who have realized its value for the development of new software and programs and, from the other side, scholars in many different "ill-defined" disciplines ask for technologies to support negotiation of understanding and enhancement of critical thinking. The relation between argumentation and digital technologies stresses the visual dimension of learning, as it is testified by the large number of software developed in the last two decades to visualize argumentative processes.

In the next two paragraphs I will introduce the practice of argument diagramming and the so called Computer-Supported Argument Visualization (CSAV) tools, which are based upon such practice.

The roots of Argument Diagramming

The "roots" of CSAV have been deeply excavated in a book entirely dedicated to the issue: "*Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-Making*" edited by Kirschner, Buckingham Shum and Carr in 2003. It is a collection of contributions from practitioners and researchers working in educational and organizational fields. It investigates the usefulness of software tools for sense-making in the construction of shared knowledge and the solving of ill-structured problems. The authors maintain that "in order to be effective, these tools must support human cognitive and discursive processes, and provide suitable representations, services and user interfaces" (see the book companion website for *Visualizing Argumentation* at http://www.visualizingargumentation.info/). "Suitable representations" seem therefore to be the proper instruments to support "cognitive and discursive processes".

In the first chapter of the above mentioned book, Buckingham Shum gives an overview of the authors who made explicit use of visual argument representations to better deal with argumentation processes in different fields. He starts from Wigmore's diagrams in the legal domain, looks over applications to computer science, mentions concept- and mind-maps, and he comes, in the end, to the IBIS system. The Issues Based Information System was the first argument mapping notation developed to encourage the open deliberation of issues. Buckingham Shum (ibidem) highlights the importance ascribed to argument diagramming and analysis by the founding fathers of today's interactive computing. For him, Vannever Bush (1890-1974) in his thought-provoking article "*As we may think*" envisioned argumentation as an application of associative linking, thus forecasting the hypertextual link which is the navigational base for many CSAV tools. He goes on identifying Douglas Engelbart (b. 1925) as having laid out "a framework for enabling people to augment their intellectual faculties by manipulating externalized 'concept structures' through a computer-supported symbol manipulation tool" (ibidem: 9).

"Argument diagrams" are diagramming techniques used to represent the reasoning structure of an argument. They are generally made up of two basic graphical components: boxes (or symbols) and arrows. Each box represents a proposition, which can be a premise (reason) or a conclusion (claim), and is joined to other boxes through arrows, which represent inferences. The final diagram usually resembles a tree having at the top the final conclusion supported by one or more reasons and objections. The whole network of boxes and arrows gives an overview of the chain of reasoning in a given argument.

Reed & Rowe (2004) depicted a genealogy of approaches to argument diagramming, trying to identify those scholars who influenced its development. They consider Richard Whately (1787-1863), an English logician and Anglican Archbishop of Dublin, as being the originator of most of the modern approaches. In Appendix III of his textbook *Elements of Logic* (1836), entitled "Praxis of Logical Analysis", Whately described a method to figure out the "chain of arguments" based on the backward reconstruction of the reasoning trace. He conceived the method to help his students in the identification of the grounds (premises) for an assertion (conclusion). Reed & Rowe then identify three branches in the genealogical tree which are more or less rooted in Whately's style: Wigmore's mechanism for detailing the structure of legal cases, Toulmin's six-parts structure for understanding field-dependent reasoning, and Beardsley's diagrammatic summary of argument structure. Let's briefly meet each of them.

In 1917 the legal evidence theorist John H. Wigmore used diagrams to represent the proof-hypothesis structure in legal matters. His interest was to find a method to provide the validity of the hypothesis given the factual evidence (ibidem); therefore, he elaborated a mechanism for detailing the structure of legal cases, including explicit marking of prosecution and defense, categorization of evidential types and an indication of probative strength. Wigmore is considered the practical founder of the technique, since his evidence chart is what is now called "argument diagram". Buckingham Shum (2003) points out that Wigmore's method doesn't aim at evaluating arguments nor leading to conclusions, but it is "a cognitive tool for reflection".

In the text *The uses of argument* of 1958 Stephan E. Toulmin proposed a new model for the layout of arguments, made up of six components: claim, data, warrant, qualifier, rebuttal, backing. The importance of Toulmin's approach lies principally in the function of the warrant, that is a hypothetical statement, which licenses an inference from a datum to a claim. With the warrant Toulmin reintroduced the concept of "enthymeme", which dates back to the ancient rhetoric, and refers to a syllogism having an implicit component. Toulmin set out a paradigm of rational argument which is not the necessary outcome of a deductive or inductive procedure, but rather an argument that can be defeated. Together with Perelman, he re-opened the way to the study of argumentation. Toulmin's model has been appropriated, adapted and extended by several scholars in different domains (Hitchcock & Verheij 2006). Relevant for the developing of argument diagramming techniques is the innovation introduced by Freeman in the '90s. He clarified the distinction between linked and convergent arguments, which is closely connected with the problem of argument evaluation (Reed et al. 2007).

In 1950 the American philosopher of art Monroe Beardsley analyzed diagrammatically a text in his book *Practical Logic*. He identified different kinds of links proceeding from reasons to conclusion, so providing the first explicit account of basic types of argument structure and how they can be composed. He used the graphs to teach how to organize the reasons for a claim and to aid in the detection of fallacies. The model yet left no room for controversial passages or for passages needing evaluation or support, since the structure of the reasoning followed the logical deduction. It was later extended for pedagogical purposes by Scriven, Johnson & Blair, and became with Walton the ground of *informal logic* (ibidem).

Let's come now to the modern practices of argument diagramming and to the respective software applications.

Software for Argument Diagramming

The practice of diagramming arguments has revealed to be a powerful method to structure reasoning and to analyze arguments, but it is a laborious task, especially when texts are complex and rich of information, and it is largely influenced by the style of the "diagrammer". During the last two decades a number of software applications have been developed in order to support argumentative processes. Among them are DSS, implemented to enhance collaborative sense-making in business and organizational contexts, and CSAV tools, which are principally education-oriented, even though they have found application also in business activities. Furthermore, some tools rise from specific domains, such as the legal one, where they were used to map legal evidences and to organize pleadings.

With the generic term of "argument diagramming tools" (AD tools) are meant those software interfaces which function, ideally, as "cognitive" tools. They lead users in constructing, examining, and manipulating external representations of their knowledge. Technically speaking, they are software implementations of representational *notations* that provide sets of primitive elements out of which representational artifacts can be constructed. The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational *artifacts* in the tool (Suthers 2003).

Even though the visualization opportunities given by the AD tools seem to represent a valuable support to accomplish different tasks, the current state of research counts only a few empirical studies investigating their effectiveness. Some studies with meaningful statistical evidences have been conducted at the Melbourne University and at the Monash University (Twardy 2004) (van Gelder 2003), demonstrating the effectiveness of a computer-supported argument diagramming method in enhancing students' critical thinking skills. They developed a method called Reason! to teach critical thinking, which consists mainly of intensive practice on the Reason!Able software for argument mapping in a highly-structured setting. Results show a real improvement, since students' gains were above the expected gains for one year in a critical thinking university class.

Different results come from the studies conducted to test the effectiveness of the ITS LARGO. LARGO was conceived to support the improvement of legal argumentation skills providing a support for diagramming transcripts of US Supreme Court oral arguments, and thus facilitating analysis and reflection. Pilot studies conducted in the fall of 2006 indicated that students familiar with the software performed better in the Law School Admission Test (Pinkwart et al. 2008). Nevertheless, following more structured studies didn't confirm the hypothesis that graphs are better than text for learning complex argumentation skills. They were identified three reasons for the difference, which relate on: student motivation, engagement with the system and post-test design (Pinkwart & Lynch 2008). When considering the success or failure of CSAV tools, Buckingham Shum points out quite the same elements to be taken into account: training in the software and incentive to use it, user's expertise in the argument mapping approach, the kind of problem tackled and the respective domain peculiarities (p. 19).

In their attempt to design a comprehensive approach to implement computer-supported collaborative inquiry in the classroom, Suthers et al. (1995) point out three reasons for using a diagrammatic interface. The reasons they give can be extended to the whole of the tasks supported by AD tools, e.g. enhancing critical skills, facilitating deliberation, supporting argument analysis and evaluation. Diagrams, they say, are a *cognitive support*, since they help students to concretely represent and internalize the abstract structure of theories and related arguments, and to keep track of them while working on complex issues; ideas and relationships are reified, that is they are represented as objects helping students to identify the overall structure of an argument and to point out weaknesses or lacks. Second, diagrams give a *collaborative support* by providing a shared context to keep track of the students' contributions to the discussion, and a reference point to facilitate reference to ideas under discussion; besides that, they reinforce peer motivation since the documents produced can later be used by other students. The third reason (*evaluative support*) relies in the opportunity to evaluate students' understanding of scientific inquiry – that is the argumentative process - as well as of a topic area – the issue which is argued upon.

The last step to take before presenting a taxonomy to classify AD tools is to describe some of them. In the next four sub-paragraphs I will briefly introduce four software specifically developed to visualize argumentation, i.e.: Araucaria, Belvedere, LARGO and Rationale. I choose them because they are among the most popular in the field having a comprehensive literature, and because they sufficiently differ from each other, this way almost representing ideal types to be classified following the taxonomy. I will, in fact, later apply to them the criteria of the taxonomy, in order to make a first test of them.

Araucaria

It has been developed in the Argumentation Research Group at the University of Dundee, principally by Glen Rowe and Chris Reed. It is based on a representation format, the Argumentation Markup Language (AML), formulated in XML. It is designed to support different typologies of users in analyzing the structure of textual argument, since it adopts a "pluralist" approach, in the sense that it does not rely on a single technique to diagramming arguments but rather tries to support multiplicity among differences that result from deep theoretical disagreement. It allows the editing and creation of sets of scheme, and the evaluation of the strength of an argument.

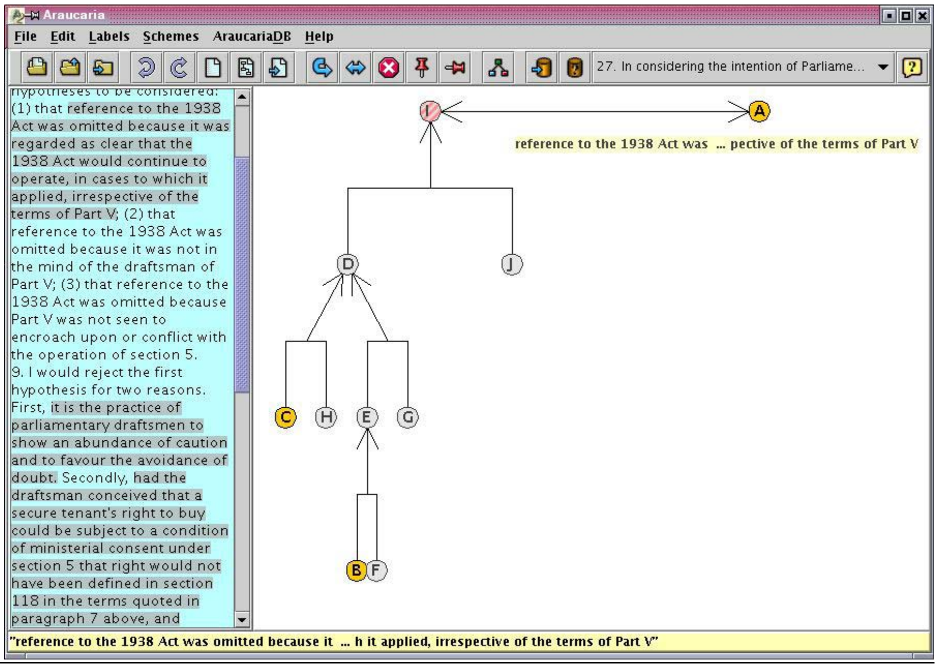

Figure 1: Argument diagram developed using Araucaria

Belvedere

It was originally developed by Dan Suthers and colleagues while at the Learning and Resource Development Center at the University of Pittsburgh. Its main goal is to support students between 12 and 15 years old to conduct scientific inquiry throughout collaboration and cooperative problem-solving. To do that, it provides a shared workspace where students working in team can coordinate and record their collaboration in scientific inquiry. The shared workspace allows to relate data and hypotheses on a consistency/inconsistency evaluation, and provides other features as an artificial intelligence coach which gives advice on demand, a chat to facilitate discussions and an access to web facilities (Suthers et al. 1997). The workspace is networked so that each student of the workgroup has equal opportunity to input and so that students can focus on and discuss the same claim being modified without losing the track of the discussion (Suthers et al. 1995).

LARGO

LARGO is the acronym for Legal ARgument Graph Observer. It is an Intelligent Tutoring System for legal argumentation born from the collaboration of experts [1] in the legal field and in human-computer interaction, with the aim of engaging law students in analyzing and reflecting about examples of expert Socratic reasoning. The examples are taken from US Supreme Court oral arguments transcripts, since they follow a test-hypothetical structure which provides complex examples of the argumentative reasoning law students should acquire (Ashley et al. 2007). LARGO allows the diagrammatic representation of this complex kind of argumentative reasoning and gives feedback, thus fostering reflection and emulation.

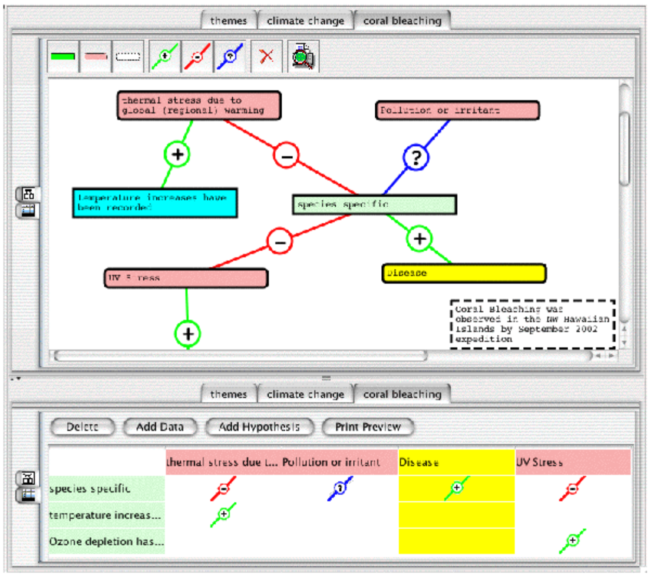

Figure 2: Argument diagram developed using Belvedere

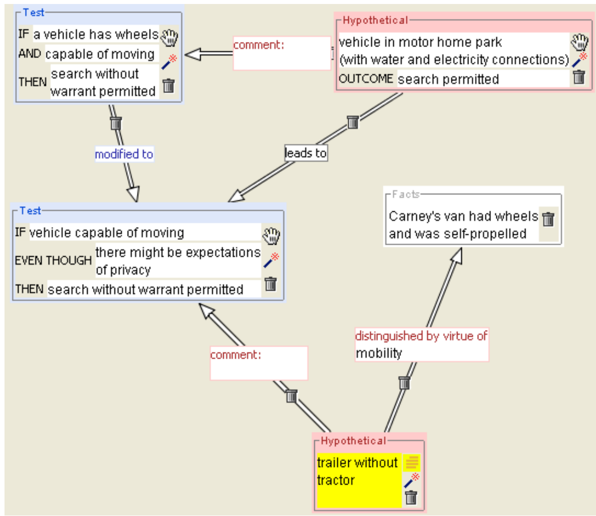

Figure 3: Argument diagram developed using LARGO

Rationale

It is the last version of Reason!Able, a software developed at the University of Melbourne and Austhink (the Australian Thinking Institute) by Tim van Gelder and Andy Bulka, within the Reason! Project. Since the project main claim was that critical thinking skills improve with the right kind of practice, the authors set up a "quality environment" – the Reason!Able software - in which students could engage in reasoning tasks more effectively than in other contexts. Rationale allows users to build, modify, evaluate and store argument maps in an easy and rapid way; "you might think of it as a *thought* processor, helping students structure their thinking in more systematic and logical ways" (van Gelder 2001: 4).

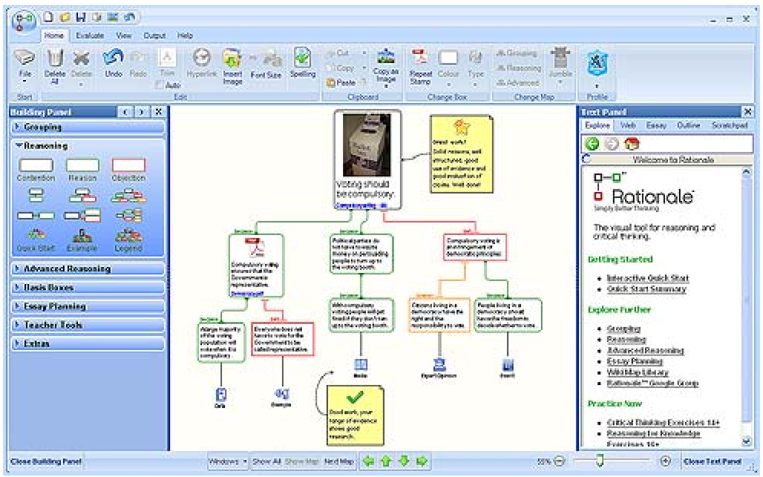

Figure 4: Argument diagram developed using Rationale

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[1] Vincent Aleven from the Human-Computer Interaction Institute of the Carnegie Mellon University, Kevin Ashley from KRCD School of Law of the University of Pittsburgh, Collin Lynch from the Intelligent Systems Program of the University of Pittsburgh, and Niels Pinkwart from the Computer Science Institute of the Clausthal University of Technology.

Each one of the above mentioned software will be better characterized in the next paragraph, where a definition of the taxonomy criteria will be given; they will serve, in fact, as examples to which apply the criteria.

Towards a taxonomy of argument diagramming tools

The taxonomy I propose looks at the argument diagramming tools from the educational and the argumentative point of view, searching for meaningful criteria which can help in finding those software most suitable for specific educational goals. The criteria answer to the following questions:

1) upon which argumentation model has been the tool developed? → *model of argumentation*
2) which is the domain of reference of the tool? → *field-orientation*
3) what was the tool designed for? → *goal*
4) what level of guidance does the tool provide for diagramming and evaluating arguments? → *guidance*

Tool	Model of arg.	Field-orientation	Goal	Guidance
Araucaria	mixed	Public: argumentation theorists Subject-field: versatile	Analyze the structure of textual arguments	Evaluation: yes Advice: no
Belvedere	Toulmin	Public: students between 12 and 15 years old Subject-field: science and public issues	Support development of scientific argumentation skills through the collaborative problem-solving	Evaluation: comparative coaching Advice: on demand
Largo	Test-hypotheticals structure	Public: American law students Subject-field: legal practice	Help students to learn skills of legal reasoning with hypotheticals	Evaluation: yes Advice: self-explanation prompts on demand
Rationale	Standard tree-structured diagram → Beardsley	Versatile	Improve critical thinking skills, enhance deliberation	Evaluation: yes Advice: online and outline help on demand

Table 1: classification of four Argument Diagramming tools following the taxonomy

Model of argumentation

The key structural elements of an AD tool are the representational notation and the representational artifact (Suthers 2003):

1. *representational notation*, is a kind of legend containing the primitives, that are the objects and relations which can be used to draw the diagram, and the rules that govern the combinations allowed between them. In Rationale, e.g., premises and conclusions are represented through boxes of different colors, while in Araucaria they are depicted through circles and alphabetic letters. Both Rationale and Araucaria allow to point out the difference between linked arguments (where several premises are required together to support the conclusion) and convergent arguments (where multiple premises act independently to support the conclusion), while LARGO distinguishes among some different types of arguments in a test-hypotethicals structure.
2. *representational artifacts*, are the outputs of the diagramming process, the external representations of specific argument patterns built by the users. They can be, for example, argument maps, Toulmin-like structures, evidential diagrams.

The representational notation depends, in most of the tools, on the argumentation model the developers decide to follow. No two software implement exactly the same schema for diagramming. Some of them attempt to integrate different approaches, as it is the case for Araucaria, some others diverge only superficially, some even doesn't rely upon a specific model, as usually happens for generic conceptual maps.

As mentioned, Araucaria adopts a "pluralist" approach, in the sense that it doesn't rely on a single technique but tries to integrate different models. (Reed & Rowe 2007: 14) The authors did a fine work of "model translation" to implement a common representational notation. They observed that the most common diagramming technique has not an official name, but corresponds to the Beardsley's method; starting from it, they analyzed and translated the key features of the other argument models, i.e. Toulmin's, Pollock's and Wigmore's diagrams.

For what concerns Belvedere, the authors state that "the graphical form [they] provide for argument representation are loosely based on the analysis developed by the philosopher Stephen Toulmin. [They] […] have adapted Toulmin's fundamental representations to scientific argumentation." (Suthers et al. 1995: 2).

Since Largo has been developed with the exact goal of diagramming the transcripts of U.S. Supreme Court, it works unfolding a test-hypotheticals structure. In the literature there weren't found any reference to specific argumentation models, but it seems to share with Wigmore both the general characteristics of the legal domain and some specific features of his charting method.

No explicit account to any argumentation model have been either found in the literature describing Rationale**.** "It is a generic tool, similar to a word processor. […]It is in the same broad space of generic concept mapping tools such as *Inspiration*, or mind mapping tools such as *MindManager*™, but focuses exclusively on reasoning and argument." (van Gelder 2001: 4) The final artifact is a tree with the conclusion of the argument as the root node supported by other nodes as premises; premises can reinforce the conclusion (reasons) or put it in doubt (objections), and can be convergent or linked. According to Reed and Rowe (2007), such kinds of diagrams correspond to the "standard" Beardsley's account.

Field-orientation

The domain of reference the tool is designed for depend on the public it addresses – at least the *public* it was initially conceived to address – and the *subject-field* such public is intended to act in.

Araucaria has been designed to support different typologies of users in analyzing the structure of textual arguments, that are considered to have intrinsic features depending on the subject-domain. In fact, it was used in many different domains; it counts applications in education, legal practice, engineers building safety cases, barristers preparing cases, doctors conducting complex diagnoses, statisticians representing test designs for diagramming arguments under an appropriateness assumption.

Belvedere focuses on students between 12 and 15 years old and its design "*addresses the cognitive and motivational limitations and requirements of these unpracticed beginners*" (Suthers et al. 1995: 1); students are principally engaged in critical discussions of science and public issues.

LARGO ITS is a good example of a domain-specific tool, since it has been conceived to cope with a problem encountered in the American schools of law. There, law-teachers usually instruct students by engaging them in Socratic classroom dialogues, which intend to imitate court-room arguments, but they seldom make explicit the argumentative process, so that students are left the responsibility to later reflect on it. LARGO supports students in the process of diagramming and analyzing US Supreme Court oral arguments transcripts, this way capitalizing the pedagogical value of argument diagrams.

Rationale was initially designed to be employed in undergraduate critical thinking classes, and then "*picked up and used in many different contexts and at many different levels, both inside and outside the academy*" (van Gelder 2002: 86).

Goal

If the generic goal of any tool for argument diagramming is just to support the representation of arguments, each of them sets one or more specific goals corresponding to the needs of the public and the subject-field addressed.

Belvedere aims at helping students to learn to conduct scientific inquiry by enhancing collaboration, in this way supporting the cooperative problem solving.

LARGO ITS intends to guide students in the process of analyzing and diagramming US Supreme Court oral arguments transcripts, thus training them in legal reasoning with hypotheticals.

As already noted, Rationale was initially designed to be used in critical thinking training, and then applied to different contexts, such as working groups dealing with deliberation in complex situations. Van Gelder (2003) reports of the experience of a factory which made a switch in the operation mode; this switch led to a general internal disagreement that was handled in a more effective way thanks to the visualization of all the arguments arisen around the main issue. The argument mapping process allowed to create a common understanding among participants and reach consensus.

Differently from the formers, Araucaria isn't properly an educational tool, but it rather poses a theoretical goal, that is to support both teaching and research in argumentation theory. "*The assumption behind Araucaria follow the same pattern: a single text might be analyzed in several different ways, depending upon a variety of analytical choices*" (Reed & Rowe 2003: 985). The general goals is to support the reconstruction of argument schemes, in order to allow transversal analyses and considerations.

Guidance

The level of guidance is strictly related with the representational notation and with the finality of the software. It refers to the interaction between the learner and the representation. Here I take into consideration two aspects: *evaluation* and *advice.*

Evaluation is an important phase of the argumentative process, since it puts into question the validity and the sustainability of the arguments advanced to support or object to a claim: both the logical chain and the topical scheme of the argument are considered (Rigotti 2009). The name “tópoi” dates back to Aristotle and refers to typical argumentation schemes used to argue about an issue. Araucaria supports labels – e.g. “presumably” - on diagrams next to the node or arrow which can be used to express the confidence placed in the premises, and allows to define argumentation schemes and to group them together into schemesets (Reed & Rowe 2003). Rationale provides a set of symbols each of them recalls a specific tópos – e.g. the “argument from expert opinion” is represented by a laureate stylized little man. Belvedere allows a “comparative coaching”, in the sense that it provides an inquiry diagram by a subject matter expert, and stirs up students to compare and discuss their diagrams with that one.

Since argumentation is not a deductive-formal reasoning and is not based on necessary statements, neither its syntactic nor its semantic flaw can be automated; only suggestions or theoretical indications can be provided to support argument diagramming. An automatic system, indeed, cannot say if an argument is good or bad to support a conclusion; it can, however, advice if a claim lacks of premises or if there are inconsistent relations among components. LARGO ITS provides feedback in the form of self-explanation prompts that can be required by the user. They encourage reflection about the diagram and alert students about misconception, e.g. if they failed to link a hypothetical node to a test. Belvedere also gives advice on demand which concerns ways in which an argument can be extended or revised, and is phrased as suggestions and questions.

Conclusions

The revival of argumentation theory in the second half of the last century facilitated the investigation in the so called “ill-defined domains”, which had been before almost excluded from the scientific discourse, because they were considered irrational under the Cartesian paradigm. In the last two decades a large number of software applications have been developed to support the solving process of “ill-structured problems”. They capitalize the pedagogical power of visualization allowing the representation of arguments. They are termed differently, depending on the focus the authors give on them; among the others, there are the family of DSS, the group of CSAV tools and generic concept-map software. In this paper I decided to address them with the collective word of “argument diagramming tools”, since they all share the general goal of supporting the representation of arguments.

The roots of the argument diagramming technique have to be found principally in the argument models of four authors: Whately, Wigmore, Toulmin and Beardsley. They influenced the modern practices of argument diagramming and are the base of software development. The practice of diagramming argument is a powerful method to structure reasoning, thus facilitating a series of learning tasks, both collaborative and analytical. The taxonomy here proposed intends to give a method to arrange AD tools. Four of them served as tests to prove the effectiveness of the taxonomy. Future work will have to classify a larger number of AD tools, in order to provide an instrument to steer teachers and researchers in different fields in finding the most suitable software to reach their pedagogical goals. A systematic comparative study is also needed to investigate the effectiveness of AD tools, since the elements for their success or failure are so far unclear.

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