COMPUTER-BASED REASONING SYSTEMS: AN OVERVIEW

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ABSTRACT: *Argumentation is nowadays seen both as skill that people use in various aspects of their lives, as well as an educational technique that can support the transfer or creation of knowledge thus aiding in the development of other skills (e.g. Communication, critical thinking) or attitudes. However, teaching argumentation and teaching with argumentation is still a rare practice, mostly due to the lack of available resources such as time or expert human tutors that are specialized in argumentation.*

Intelligent Computer Systems (i.e. Systems that implement an inner representation of particular knowledge and try to emulate the behavior of humans) could allow more people to understand the purpose, techniques and benefits of argumentation. The proposed paper investigates the state of the art concepts of computer-based argumentation used in education and tries to develop a conceptual map, showing benefits, limitation and relations between various concepts focusing on the duality "learning to argue – arguing to learn".

KEY WORDS: *argumentation; computer systems; learning.*

JEL CLASSIFICATION: *D83, L86*

1. INTRODUCTION

The theoretical foundation of Argumentation research can be found in the well-known work of Stephen Toulmin – "The Uses of Argument", firstly published in 1958 with an intention that was "strictly philosophical: to criticize the assumption [...] that any significant argument can be put in formal terms: not just as a syllogism [...] but a rigidly demonstrative deduction of the kind to be found in Euclidean geometry" (Toulmin, 2003).

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Those expectations have been greatly exceeded, with argumentation finding its way into a wide area of research, from law to philosophy, from rhetoric and education to computer science.

Consequntly, we find that argumentation theory can provide valuable educational tools, especially in domains that are "ill-defined" i.e., domains that "lack a systematic way to determine when a proposed solution is acceptable" (Lynch, et al., 2006) such as communication, critical thinking, music appreciation, ethics or even law. The limitations related to using argumentation in education (eg. lack of resources) can be overcome by the use of specialized computer systems that either help in the representation of argument structures or even generate new arguments or make automated analysis of an argument structure.

The current paper tries to provide a review of the ways argumentation and learning are connected and what are the latest developments in the specialized computer systems that use argumentation tools to enhance education.

2. ARGUMENTATION AND LEARNING

2.1. Scaffolding learning with argumentation

From the point of view of the education process, we can distinguish two types of argumentation: the competition argumentation, where the purpose of the participants is to convince their counterparts to assume their position on a specific topic and the collaborative argumentation, where the purpose is to test all possible ideas regarding a topic in order to reach the best possible outcome.

The competition type argumentation is the more visible type of argumentation in day-to-day life. Political candidates oppose different views on TV, people have opposing opinions on whom to trust and what course of action to take in various moments. Since the goal of such arguments is not to work together toward a common position, but simply to score points in order to convince either the opponent(s), or in some cases (as in politics) the public, it has been argued (Andriessen, 2006) that this type of debate has little to none educational benefit.

However, since the purpose of any competition is to be won, winning an argument is a strong motivation for learning new concepts and facts that can support one's claims or help to refute the opponent's arguments. There is also a secondary learning benefit from competition arguments: even if one researches a specific topic and tries to understand all issues related to it, a different person might take a different approach and still come up with new information.

However, one must take into account the fact that, the manner in which the opponents will be lead to expand their knowledge in order to win the argument is strictly related to the context of the argument:

- a formal debate competition requires strong scientific preparation that may lead all involved parties to try to get a deeper understanding of all issues relating to the topic;
- an informal debate may not have such a positive educational effect, but could even create more confusion since "many people have trouble arguing productively.

They are not good at distinguishing evidence from theory, and do not tend to consider alternative positions " (Andriessen, 2006).

In the case of collaborative argumentation, since the purpose is not to win or convince the opposition or the public, the educational effects are even more obvious. The participants are not primarily attempting to convince each other, they are instead engaged in cooperative explorations of a dialogical space of solutions (Nonnon, 1996).

Collaborative argumentation has been found to have an important role in research – advances in science is not obtained by the accumulation of facts, but by opposing different views and testing their strengths and limitations with the help of peers.(Bell, 2004)

Another interesting observation is that argumentation fosters transversal learning, by forcing the participants to put together in a logical fashion, data, concepts and knowledge from various domains. To back their positions or contradict the opposing positions, participants must find different types of proofs, from expert opinions to statistical data or demonstrations, which in turn exposes them to more information and leads to the construction of deep understanding.

2.2. Direct application of argumentation in education

Argumentation and its related techniques and methods have obvious limitations in the possibilities of being implemented in formal educational settings. Using argumentation one could not possibly learn how to solve a second degree equation and it would be of no use in trying to master a programming language. Thus argumentation is useful especially in ill-defined domains as defined above. Most studies so far investigated the use of argumentation in three major areas: critical thinking, law and essay writing, though it seems plausible that it can be used in other domains, such as music appreciation, ethics, philosophy or others.

Critical thinking is a domain with a fair amount of attention, even though "there is no generally accepted, well-defined list of skills that constitutes the set we call 'critical thinking skills'" (Harrell, 2007). For the scope of this paper we will consider critical thinking as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven, 1987).

The practice and education of law is also linked with the theory of argumentation. There are several computer-based systems such as Carneades (Gordon, et al., 2007), ArguMed (Verheij, 2003) or LARGO (Pinkwart, et al., 2006), that reported good results in teaching legal argumentation by means of tests that interpret

laws, legal principles, or precedence cases in a specific way to decide the current situation at hand (Scheuer, et al., 2010).

Essay writing is another ill-defined domain where argumentation proved to be an effective method of learning, with studies showing that students who used this method performed better at writing esseys than student who studied philosophy in a traditional manner, even with less writing practice (Burns, 2012).

3. COMPUTER – BASED REASONING SYTEMS

3.1. Rationale of developing Computer-based Reasoning Systems

By Computer-based Reasoning Systems (CBRS) we understand any computer application that can be used to support the creation, practice, analysis or graphical representation of an argument structure. Such systems have started being developed in the late '80, following the advances in artificial intelligence, with two main goals in mind: to instruct people – both in argumentation itself, but also in other subjects such as law and to help with the decision – making process in complex, unstructured problems. The evolution of CBRS refined their rationale, that we have summarized in the points below:

- *Education*: CBRS act as a practice field for skills such as critical thinking.
- *Research*: CBRS are being used in research both as collaborative tools, allowing researchers to oppose views in a structured environment that may lead to the new ideas or solutions (Gordon, et al., 2007).
- *Productivity*: CBRS are being used in the corporate environment as productivity tools, either as Decision-support tools (Moon, 2009), either to act as support for meetings and other forms of dialogue-based collaboration (Conklin, 2006).
- *Mixed*: many systems might have two / three layers – a productivity system can be used in corporate training so it has an educational purpose; a system that implements a formal argument model can be used to investigate the strengths and limits of said model and so on.

3.2. Types of Computer-based Reasoning Systems

When analyzing the different types of CBRS, we looked at both form and functionality, to get a better picture of how these systems are organized, how closely they follow a specific theory of argumentation and to what degree they can provide automation to tasks such as argument creation or argument analysis / evaluation.

The following points summarize our findings:

- Strict systems: focused specifically on argumentation; modeled keeping argumentation theories in mind. They are less flexible (i.e. users can only use them in argumentation-related contexts) and more formal.
- Automated reasoning systems: automatically perform reasoning on the basis of the information in their 'knowledge base'. Examples: Carneades (Gordon, et al., 2007), ConvinceMe (Adams, 2003).
- Argument mapping: allow the creation of argument maps - graphical representation of an argument structure. Examples: iLogos (http://www.phil.cmu.edu), Raționale (rationale. austhink.com), Araucaria (rationale.austhink.com/).
- Argument assistance: systems that aid in drafting and generating arguments, by administering and supervising the argument process. Examples: ArguMed (http://www.ai.rug.nl/ ~verheij /aaa/argumed3.htm).
- DMS – debate management systems: content management websites specialized on asynchronous argumentation; they are usually human-maintained and serve as "practice space" for any user that wants to debate a given issue. Examples: Debatabase (idebate.org), Truthmapping (truthmapping.com).
- Loose systems: systems that have a broader scope and allow different types of relation definitions not related with a specific theory, such as mind maps. Examples: Cohere (http://www.cohere. open.ac.uk/), DialogueMapping (Conklin, 2006).
- Derrivative: systems that are complementary in some way to CBRS. They focus on specific sub-points (e.g. logical proof, causality) but do not implement a full reasoning-model. Eg.: APROS (http://cohere.open.ac.uk/), Causality Lab (http://cohere.open.ac.uk/).

3.3. Main CBRS with focus on education

During the last decade, there have been developed more than a few interesting Computer-based Reasoning Systems with focus on education. However, some of these have been discontinued and even if they can still be found on-line, we believe it is best to focus on the most updated and document systems that can be used by researchers and educators in their own projects.

The main systems we have identified are summarized in Table 1.

Table 1. Educational computer-based reasoning systems overview

System	Type	Purpose (education)	Automation	Obs.
Rationale	Argument Mapping	Critical Thinking, Essay writing	No	Update for Reason!Able http://rationale.austhink.com/
LASAD	Mixed: implements visual, analytic, and pedagogic components	Background in law-argumentation; updated to a broader scope including critical thinking and argumentation	YES	Update for LARGO. Domain independent. http://cscwlab.in.tu-clausthal.de/lasad/
Carneades	Automated reasoning	Argumentation. Focused on the legal domain	YES	http://carneades.berlios.de/
Argunaut	Argument assistance	Cross-domain learning objectives	YES	http://www.argunaut.org
Wise	Mixed: concept mapping, debate management	Cross-domain collaborative learning	NO	implements several other tools (e.g simulations) http://wise.berkeley. edu

4. CONCLUSIONS

The current paper focused on analyzing the connections between argumentation and education, emphasizing the importance of argumentation in critical thinking, essay writing, law and other ill-defined domains. Since such topics are difficult to teach in a traditional manner we looked for possible computer-based solutions.

We have found a strong interest in developing and implementing computer systems that use some theory, method or representation of argumentation as educational tools - Computer-Based Reasoning Systems. While not all CBRS are used in education, most have at least some educational benefit. Since they vary in type and domain of, we have summarized the main types in order to provide a map of what is achievable and through what means.

We have also looked at the main systems developed in the last decade or more and found an interesting fact: most systems have been abandoned after periods of testing and research, mostly due to the fact that they have been seen as research experiments in the first place. Although some of these can still be found, it is highly unlikely that they can be used in education or can be developed further.

From the systems that have been updated we chose to highlight five systems, one of each major type, that could be used directly in the classroom (with just a little training) or could be used as a starting point for new research into learning by argumentation.

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