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Digital Tools for Written Argumentation

Kalliopi Benetos

Abstract Digital tools for argumentative writing aimed, from early on, to support the use of argumentation to develop knowledge about the topic being argued. Many products were initially created to serve research purposes, and few developed in the last thirty years have made it to the educational technology market for use by instructors and writers. Others are reserved for institutional use or have become obsolete. More recently, research in argumentative writing has moved away from digital platform development specifically aimed at argumentative writing, to simpler generic diagramming and collaboration tools to be integrated in learning activities. Development has focused more on analytic approaches to generating representations of writing (processes and products), while research has shifted towards strategy instruction and related design principles. A selection of differing environments developed to support argumentative writing will be presented to highlight the evolution and the gaps in digital tools for written argumentation.

Keywords Computer-supported argumentation · Digital authoring tools · Written argumentation

1 Introduction

Argumentation has been used for millennia as a means of investigating claims through critical thinking to arrive at informed decisions and build knowledge. Argumentative writing is used in a wide range of academic contexts as a means to develop, convey and measure an individual's learning and understanding of a selected topic. While the structures, practices and conventions of argumentation may vary from one domain to another (for example in Law, Science or Medicine), written argumentation is valued as a pedagogical approach because it calls upon cognitive and meta-cognitive processes demanded by both writing to learn and argumentation. It

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also calls upon cognitive and metacognitive skills particular to written argumentation such as goal setting on the topic and task level (Bereiter & Scardamalia, 1987; Felton & Herko, 2004; Galbraith, 1999), and the acquisition and application of knowledge of the structure of discourse and its components (Bereiter & Scardamalia, 1987; Flower et al., 1986). It also involves the recall and reconstitution of domain-specific knowledge and the evaluation of the validity of arguments and counterarguments (Limon, 2001), as well as a self-evaluation of both process and learning goals (Flower et al., 1986) and the capacity to engage in and self-regulate metacognitive reflection (Felton & Herko, 2004; Karoly, 1993; Limon, 2001). It offers the opportunity to consider multiple perspectives and to confront, reason and resolve contradictions that arise so as to expand and deepen knowledge and enable changes in conceptual understanding (Andriessen, 2006; Kuhn, 2001; Leitão, 2000; Scardamalia & Bereiter, 2006). Engaging in argumentative writing thus requires that a vast range of skills be learned in order to engage the critical thinking and writing strategies needed to produce academic level argumentative texts and learn through the processes involved.

Technologies for supporting written argumentation support three main activities: *learning to argue*, *arguing to learn* and *learning about argumentation* (Andriessen et al., 2003). Though there are numerous technologies and software to support reasoning and argument construction, our focus in this chapter is on technologies that aim more intentionally to support the development of skills necessary for writing academic texts using the argumentation genre to present and support a hypothesis or thesis statements within linear text formats of which learning to argue and arguing to learn is indisputably a part.

1.1 Background

Computer-supported argumentation technologies burgeoned in the late 1990's and early 2000's with early support for generating and analysing arguments through *markup* languages that could be used to analyze, formalize, diagram and visualize argument structures and components based on argumentation models drawn from Toulmin (1958) and Walton (2008), among others. These systems used diagramming devices to graphically organise units of information (textual nodes) and their relations (links) using visual properties to attribute to them their function in argumentation based on defined argumentation ontologies and models (Desmet et al., 2005; Gordon & Walton, 2006; Reed & Rowe, 2001; Smolensky et al., 1987). Current argumentative writing tools still embody selected models of argumentation or strategy instruction formalized in frameworks and markup languages and that are represented and rendered operational through the applications or devices within platforms or systems and the guidance they offer.

As digital technologies for delivering applications online evolved, an abundance of diagramming tools has become readily available through navigators (Cmap Tools,[1]

[1] Cmap Tools: https://cmap.ihmc.us.

Cacoo,[2] Diagrams.net,[3] Mindjet, etc.) or commonly used applications (Microsoft Word, Microsoft PowerPoint, Google Draw, Google Docs). Diagramming tools allow users to create text within shape forms or *nodes*, and join them together using arrows and lines to create visual *links* (see Sect. 2 chapter Creativity Software and Idea Mapping Technology). In parallel, argumentation systems designed specifically for diagramming argumentation and writing argumentative texts have become more heavily standardized systems or have given way to strategy instruction combined with simple generic tools to diagram and produce argumentations. In this chapter, we review several digital argumentation systems, their underlying technologies and functionalities, and discuss which cognitive and metacognitive skills are called upon and supported by these systems. We describe how such applications can generate representations of writing processes, support argumentation, and facilitate strategy instruction. Possible developments and tendencies leading to the divergence between multi-feature domain-specific systems with heavily prescribed uses, to more generic multi-purpose, readily available devices in combination with scripting or strategy-based approaches will be discussed. We argue that this use of technology reflects instructors' and learners' preference for versatility in software as opposed fully digitalized writing-support systems.

2 The Core Idea Behind Digital Systems for Argumentation

Argumentation systems often integrate multiple technologies to offer systems that include various devices and services for processes and activities related to generating or analysing argumentation. Applications and platforms offer various devices to scaffold argumentative writing, using diagramming and outlining, and prompts for generating, elaborating and linking arguments, alone or in combination with textual or graphical representations, to offer progress indicators on states and goals to be achieved and guide actions to be taken (see examples shown in Figs. 1,2,3 and 4). They provide process and product models for constructing arguments, with or without strategy instruction.

Within these digital environments, users learn through the process of written argumentation by completing tasks using the support embodied in various suggested use schemes and representations of components and actions to be taken to build arguments and argumentations. They can provide contextual cognitive aid through prompts for the development of ideas and the linguistic means to link these ideas. This is achieved in the tools themselves through diagramming, outlining and elaborating text. Knowledge is built by developing an argument, which creates the mental scaffolding for learning content.

Additionally, users of these digital argumentation tools can learn about argumentation through the representations and guidance. They diagram and outline their

[2] Cacoo: https://nulab.com/cacoo.

[3] Diagrams.net: https://app.diagrams.net.

argument to visualize it, organizing arguments according to their relationships to each other and the rhetorical goal. As such, digital argumentation systems offer support for learning and mastering the structure of discourse on the local argument level, and with regards to its function within the textual discourse moving towards a global rhetorical goal.

Finally, users learn to argue through practising reasoning and learning about the conventions of argumentation. Through various awareness tools that reveal traces of interactions, they can also be encouraged to collaborate with or solicit feedback from peers and instructors about the structure, purpose and effectiveness of the argumentative writing, and become aware of procedures implicit in the embedded scripts. This can be achieved through diagramming and dynamic feedback, as well as reading or elaborating text.

3 Examples of Digital Tools for Written Argumentation

Recently, digital argumentation tools have moved from purpose-specific systems to general interaction devices that can be exploited for diagramming, leaving guidance and strategy instruction to the classroom rather than embodied in the system. In what follows, we will present and discuss a selection of digital argumentation environments currently in use or development that support reasoning and argumentative discourse but differ in the forms and types scaffolding and representations they offer as well as their prescribed uses. By assessing the main similarities and differences in their affordances and prescribed uses, we will be better positioned to identify factors that may explain the scant and slow adoption of digital tools for argumentative writing in classroom settings. We will look more closely at the following representative sample of environments currently in use and their tools: Rationale, Endoxa Learning, Kialo and C-SAW.

With the exception of more generic concept mapping tools, the systems presented here were developed from academic research-based contexts aiming to improve argumentation skills and learning from argumentation in educational contexts (K-12, undergraduate or graduate levels) with the goal of building academic writing skills.

3.1 Rationale

Rationale is a pay-for-service web-based environment designed for "argument mapping" to support reasoning. It allows learners to create maps in order to "structure arguments," "analyse reasoning," "identify assumptions," and "evaluate evidence," (*Rationale,* 2022). Rationale is the most complex of this sampling of digital systems for written argumentation, offering templates and examples for scaffolding written argumentation in various contexts.

Rationale allows users to create and change a visual representation of their line of argument. This starts with a main argument, a claim, a position, a proposition, or a contention. Users then build on that argument by adding reasons to support their main argument to which objections can also be added. Reasons and objections can be supported by examples and additional nodes for citations or statistics.

There are three map types (argumentation schemes) in Rationale: *Grouping*, *Reasoning* and *Advanced Reasoning*. While *Grouping* allows learners to link ideas, *Reasoning* and *Advanced Reasoning* allow them to design an argumentation (Fig. 1). Rationale can be used to question the validity and clarity of an argument and its structural components. It offers an "Evaluate," menu where users can qualify or rate argument components. Rationale is not a synchronous collaborative tool, but users can share maps so they can be modified by others. It also offers note taking for idea-generation and multiple essay planning templates for various argumentation genres to guide drafting outlines and structuring the text as a whole (linearization). The text produced is visible in a sidebar and can be exported as a Word document.

Though the justification of the design and prescribed uses of Rationale are explicitly founded on research on the benefits of computer-aided argument mapping (Davies, 2009; van Gelder, 2007), much of the research using Rationale does not aim to look at the particular mediating effects of Rationale's specific devices and their affordances. Rather, it exploits artifacts and traces to examine the effects of computer-aided argument mapping in general on thinking and writing (Lengbeyer, 2014; Maftoon et al., 2014).

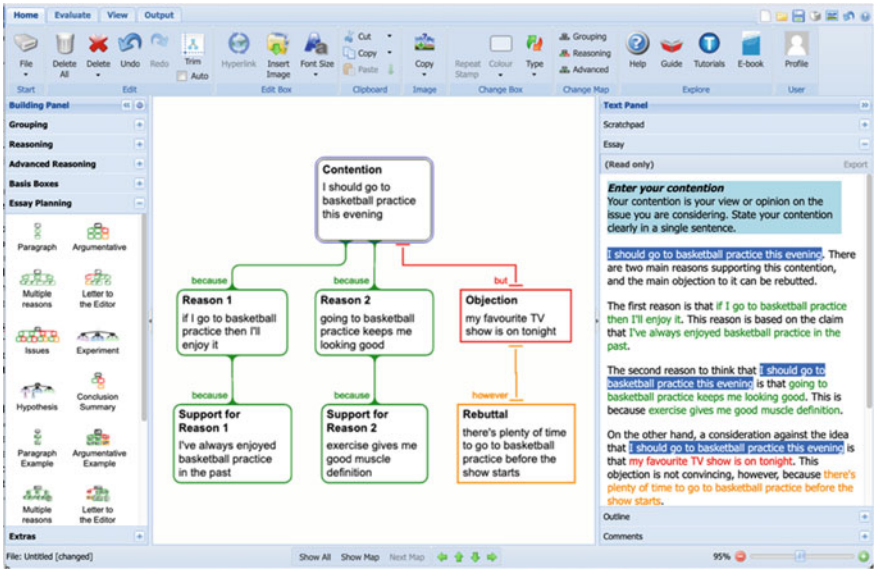

Fig. 1 Rationale interface showing categories of argumentation schemes and essay support

3.2 *Endoxa Learning*

Endoxa Learning is a relative newcomer to the domain of argument diagramming (graphing). Aimed at improving academic argumentation by scaffolding reasoning and critical thinking, it targets primarily educational institutions. It includes off-the-shelf lesson plans with ready-made topical argument graphs based on an existing corpus that learners can peruse or engage with and elaborate, and integrates quiz functionalities to evaluate learning acquisition. Unlike most argument diagramming systems, Endoxa Learning (Fig. 2), uses Walton's critical questions approach to engage reflection upon different argument types (e.g., analogy, generalizations, cause and effect) that is more adapted to hypothesis testing and problem-solving in science and engineering teaching domains, rather than the more commonly used Aristotelian thesis-antithesis-synthesis or Toulmin argumentation models. (Nussbaum & Edwards, 2011). Each type of argument presented by the user has characteristic ways in which it can be supported or undermined, and these are captured by the critical questions suggested (purple node in Fig. 2) While it currently uses some corpora for the generation of context or argument-type specific guidance prompts, further topic and domain specific corpora integration is currently under development.

Research specific to the use of the Endoxa Learning has yet to be published, but the website offers a whitepaper and a list of research publications upon which its design and development is founded (*Key Articles - Endoxa Learning*, 2022).

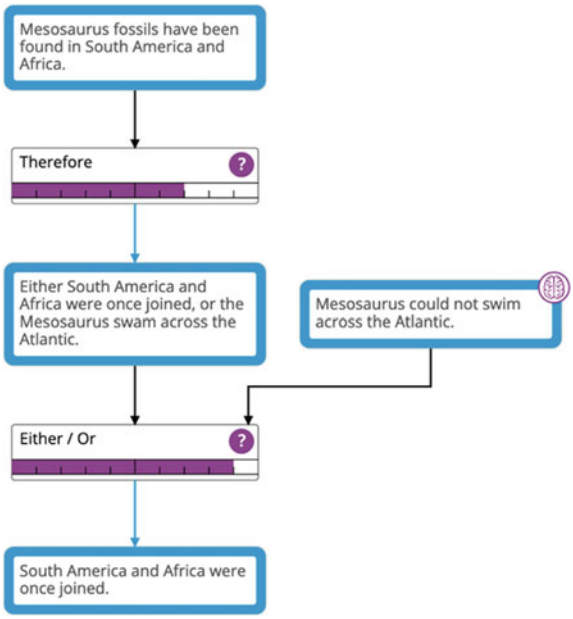

Fig. 2 An example from using Endoxa Learning a two-step argument to draw a conclusion. Questions marks raise critical questions. Brain icons call up factual information and sources

3.3 Kialo

Kialo is a web-based platform which aims to provide an environment for collaborative structured discourse and debate. While Rationale, Endoxa Learning and C-SAW focus more on guiding learners to create and modify an argument through learner-system, instructor-system and learner-instructor interactions, Kialo is based on peer feedback, and, to a lesser extent, strategy instruction. Discussions on Kialo can be public, or private and Kialo-edu provides closed debate spaces for instructors and classroom use with added class management services.

Using Kialo (Fig. 3), learners may create a thesis or join an existing discussion. Learners and their peers can add pro or con arguments to the thesis, and comment on the arguments. Arguments are nested in branches and threads that can be expanded and rearranged. The nesting visual interface, like Rationale, gives the learners a representation of how arguments in an argumentative essay are built.

Kialo offers little contextual guidance towards constructing a valid or sound argument. While it allows one to export a discussion in text format, it does not give any explicit guidance or devices for organizing a collection (branch) of arguments into a linear text.

The Help section, however, offers clarifications on what makes a good claim, how to support a claim and how to use sources, which can be considered a basic form of strategy instruction external to the application. The evaluation of the soundness of arguments relies on a peer voting system. This may raise awareness about the

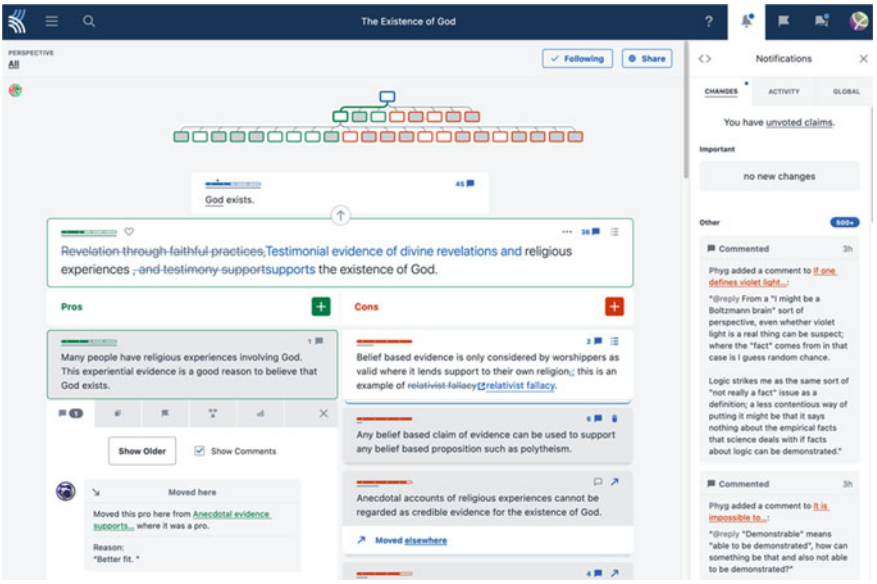

Fig. 3 Debate Structure in Kialo

target audience of a well-written arguments, but it does not provide prompts for good writing per se.

Kialo is not used exclusively for supporting written argumentation. It can also be used in different contexts for decision making. With the advent of web 2.0 technologies that spurred the social web, online debating platforms began to flourish and remain popular, but subject to short lifespans. Kialo, with its added learning management and export options has become one of the most popular digital argumentation tools, with many other similar ones available online: Acceptify,[4] Socratrees,[5] DebateGraph.[6]

3.4 C-SAW (Computer-Supported Argumentative Writer)

C-SAW, a web-based authoring software, aims to scaffold writing processes of novices within instructional designs that use argumentative writing as a pedagogical approach to develop reasoning, knowledge construction and critical thinking. It is built upon ArgEssML, an XML markup language specifically designed for developing digital tools for argumentative writing. ArgEssML and the C-SAW interface embody design principles derived from research on written argumentation, self-regulation and conceptual change and several cycles of participatory design-based research (Benetos, 2017).

C-SAW aims to help novices of argumentative text composition to develop and structure their written texts. It introduces prompts and devices designed to engage writers in the self-regulation processes that enable deeper reflection and can lead to changes in concepts and understanding. C-SAW offers a visualization and scaffolding of the composition process and product (Fig. 4). C-SAW also logs writers' actions to provide information for research or analytic purposes. It is the only system that explicitly guides the linearization process. Diagrams are generated from users' actions, but cannot be directly manipulated. Various argument schemes are available, and arguments can be reordered. There is no automated text analysis in C-SAW but there is some automated feedback in the form of various dynamically generated task completion indicators that reflect writers' actions in a hierarchical tree style diagram to give progress feedback and various textual visualizations for reviewing. C-SAW's strengths are in the contextual prompts to develop and evaluate one's argumentation with respect to the rhetorical goal and the linguistic help to link components. It also offers a teacher interface to allow instructors to modify all labels and prompts so as to adapt the language to their context and needs.

C-SAW is also one of the only tools reviewed in this chapter to have available qualitative and quantitative research studying the mediating effects of the use of its devices on argumentation, learning and writing quality (Benetos, 2014, 2015,

[4] https://www.acceptify.at.

[5] https://socratrees.azurewebsites.net.

[6] https://debategraph.org.

2017; Benetos & Betrancourt, 2020). C-SAW is currently a very highly functioning prototype that continues to be developed and tested in field studies and experimental settings using design-based research to further its development.

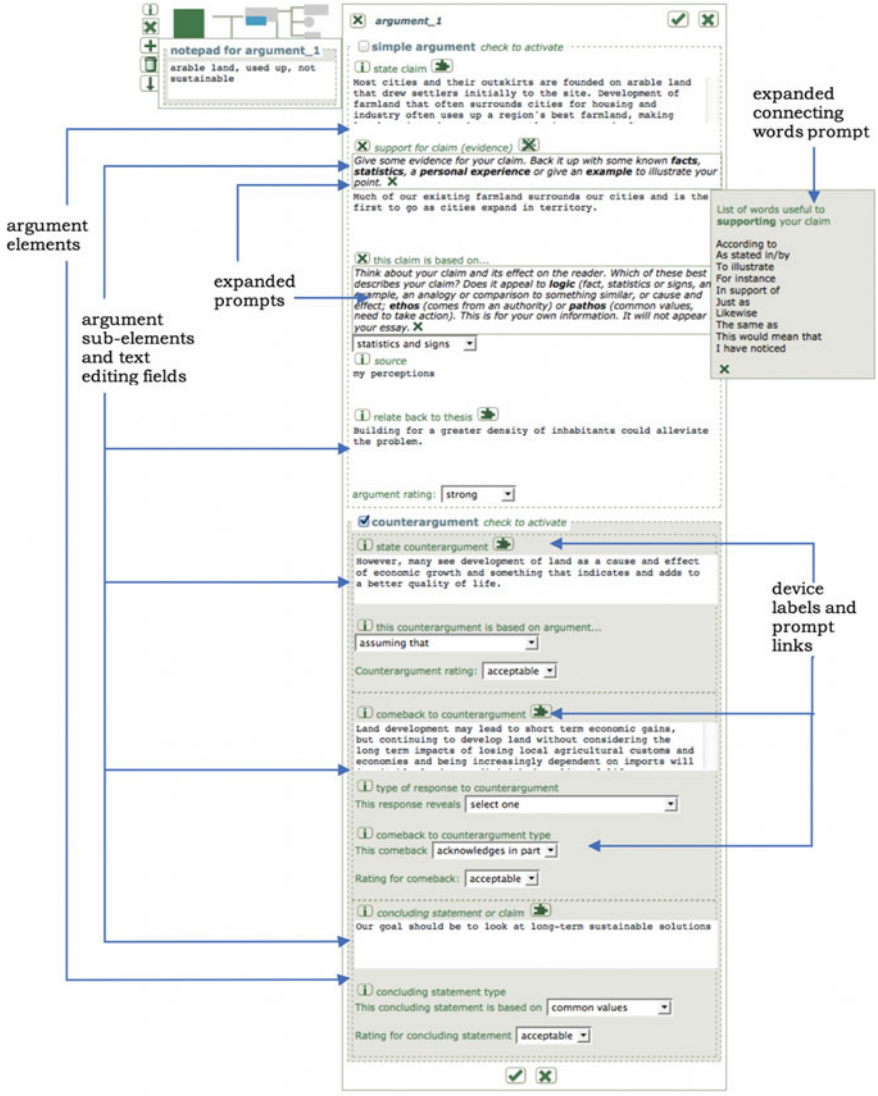

Fig. 4 C-SAW interface in editing mode (Benetos & Betrancourt, 2020, p. 305)

3.5 *Functional Specifications*

Computer-supported argumentation systems essentially mediate activities involved in the argumentative writing process by scaffolding various interactions between users and the system, with the bulk of the support being for learner-system interactions.[7]

Learner-system interactions in argumentation systems are varied in complexity and types of activities they mediate. For learner-system interactions, users are often offered linguistic and visual (graphic) prompts as progress and state indicators, task orientation, and goal-setting functionalities. Users can organize and visualize their argument by generating text in nodes, freeform, or in text input fields. The text can be rearranged by moving individual or groups of nodes. Learners may choose to analyze text through selecting, 'tagging,' and linking ideas. By being asked to agree/disagree or rate ideas related to the content or the structure of the argumentative text, learners are encouraged to look closer at a text. Linguistic markers offer contextual aid or help link nodes (concepts) and define their relationships within the argumentation. Other prompts may come in the form of 'empty' models or templates to be filled out. Learners may be asked to justify and validate their argument by adding sources. These types of prompts can facilitate content generation and elaboration and structuring the argumentation, but also act as aids for self-regulation of writing processes and self-evaluation of the argumentation produced.

The scaffolding focus of these functionalities are substantive (about the task) as well as procedural (how to achieve it). It can be substantive of the first order, i.e., they offer aid to accomplish specific tasks, or of the second order, as in the case of Writing Pal, in that they support learning for transfer (Noroozi et al., 2018). Writing Pal (W-Pal) is a web-based intelligent tutoring system that provides learners with "explicit strategy instruction, game-based practice, essay writing practice, and automated formative feedback" (Roscoe et al., 2014). Designed with a view to improve essay writing as a whole, not necessarily argument construction or argumentative writing, Writing Pal is covered in detail in the Sect. 3 chapter "The Future of Intelligent Tutoring Systems for Writing". The scaffolding focus in the written argumentation systems covered in this chapter, is more often procedural with respect to organization and structure, offering support for the execution of the conventions of argumentation, though prompts and examples given in systems such as Rationale and C-SAW can also aid transfer.

Interactions between the instructor and the system consist mostly of various analytics, and tools for the management of access, learner tasks and submissions by the instructor. The digital argumentation tools discussed also facilitate the interaction between learner and instructor, offering the instructor various forms of support in

[7] Earlier systems designed to study computer-supported collaborative learning placed a greater emphasis on devices to mediate learner-learner interactions.

providing guidance, assessment, or evaluation. To support the learner-learner interactions, in addition to collaborative editing spaces, these tools add evaluation or dialogue moderation devices (e.g., ratings/likes/votes, comments/chats) to increase social and audience awareness. In sum, digital argumentation tools that structure and diagram argumentation can be seen as both analytical and guidance tools for learning and instruction.

3.6 Technical Specifications

Whether collaborative or individual, digital argumentation systems almost unilaterally use strict to rather loose schemes of informal logic to construct or deconstruct text into argument components (e.g. Buckingham Shum, 2003; Toulmin, 1958; Walton, 2008) and translate them into diagrams based on standardized visual notations. These standards can also define guidance required to adhere to them that can be translated into features, devices or prompts to support text generation and organisation, and provide, awareness and activity mirroring tools and task completion guidance, using various representations. They may also, like KIE and VCRI, two early digital environments no longer supported, define forms of automated or peer-feedback to support testing hypotheses, collaborative debate, and knowledge building (Bell, 2000; Erkens et al., 2010).

To guide their development, digital argumentation systems use formalized frameworks that define argumentation schemes and practices in specific domains (e.g., law) or contexts, such as hypothesis testing, dialogue and collaborative argumentation or knowledge building. Frameworks such as Argunet's Argument Interchange Format (AIF) (Schneider et al., 2007) or Carneades' Legal Knowledge Interchange Format (LKIF) (Gordon & Walton, 2006), and markup languages such as Araucaria's AML (Reed & Rowe, 2001) or C-SAW's ArgEssML (Benetos, 2015), aim to define formal languages to represent argument structures and provide standards that can be interchangeable between different systems, as well as guide the development of digital tools for argumentation (Scheuer et al., 2010). In practice, needs for domain specificity or simplification has led to modifications that limit their interoperability (Chesñevar et al., 2006) and given rise to proliferation of standards (Scheuer et al., 2010). Of these mentioned, only C-SAW's ArgEssML presents a grammar for representing argumentative essays rather than just arguments.

4 Research

An important body of research and systems development to support argumentation has focused on using diagramming in collaborative learning situations (Stegmann et al., 2012) to hone general or domain-specific argumentation skills (learning to argue), showing how it can help better use argumentation to broaden and deepen

knowledge on a particular topic (arguing to learn) (Baker et al., 2003; Muller Mirza et al., 2007; Munneke et al., 2003; Schwartz & Glassner, 2003). Much of it was not specifically concerned with writing as the central activity and how diagramming tools impacted the argumentative writing process post-debate. There is also considerable research on the benefits of using diagramming to analyse argumentative texts as sources for learning and argumentative writing (Bell, 2000; Mochizuki et al., 2019; Reed & Rowe, 2001), but these studies use complex closed systems with highly prescribed and scripted uses. Scheuer et al., (2010) present a thorough state of the art of digital systems supporting the argumentation process and developing good argumentation practices (learning to argue and about argumentation) as a means towards attaining domain specific learning outcomes (arguing to learn), rather than the writing of quality argumentative texts.

Other research has looked at how argumentation systems and their devices can work as self-regulatory facilitators, providing environments for self-monitoring, metacognitive reflection, and self-management of task completion (Benetos & Bétrancourt, 2015; Soller et al., 2005). Digital argumentation tools call upon and help develop writing skills through structural and procedural supports, visualizations, and integrated linguistic tools in individual or collaborative situations, through devices that have been found to lead to more complete and justified arguments and may facilitate linearization, leading to the writing of better argumentative texts (Erkens et al., 2010).

Technology development and research seem to have highlighted the gaps in teaching strategies and instructional design around second-order learning (Noroozi et al., 2018). Feedback, whether intelligent or simply reflective of interaction, is mostly geared to what Noroozi et al. refer to as first order scaffolding to help accomplish the task at hand, with little explicit integrated guidance for transfer. The former type of feedback requires systems to analyse user interactions and products across multiple 'compositions' of diagrams and texts. While cloud-based systems can eventually provide quantitative analytics with overviews of users' contributions and productions, there remains a gap between what systems are providing and the feedback required for second-order learning. With the exception of Writing Pal (see Sect. 3 chapter "The Future of Intelligent Tutoring Systems for Writing"), to our knowledge no currently available system integrates feedback or guidance based on a semantic analysis of the content.

Research into teaching practices in the last decade, focuses more on using combinations of readily available digital tools such as simple diagramming for pre-writing and micro-level scaffolding for text elaboration, combined with various forms of strategy learning. Reed et al., (2017) present the digital argumentation landscape as an "Online Ecosystem of Tools, Systems and Services" and the plethora of social debating platforms would concur. While these may help develop argumentation skills through text, and build repositories of argumentations for further argumentation research, they do little to develop writing lengthy argumentative texts that adhere to current academic conventions and standards.

5 Commentaries: Implications of This Technology for Writing Theory and Practice

Technology acceptance and integration into practice (appropriation) are also dependent on factors external to the technology's scope of influence (organizational, attitudinal, cultural, etc.). Many digital argumentation tools have been created as part of larger research initiatives because of the interactions tracking and data collection they facilitate (e.g., VCRI). Few make it into the educational technology markets to be used by instructors outside of the host institution and if so, fail to remain financially viable. Many quickly become obsolete when the research funding ends though some can still be found in repositories such as GitHub (see List of tools). As such, instructors may resist investing time in heavy systems, and often prefer to use simple diagramming tools like Google Draw or PowerPoint because they are familiar and are readily available. An exception to this seems to be social argumentation and diagramming platforms, with reappropriations of tools like Padlet (Dewitt et al., n.d.) or resorting to LMS forums for online debates. These tools are used individually or collaboratively in pre-writing activities or to elaborate class debates to develop arguments towards a rhetorical goal (Andriessen, 2009). Here too, there are contradictory demands. Open social debates appear to be favoured by developers and researchers (Arguman.org,[8] Kialo), but the tools that seem to survive, rely on educator targeted features that restrict and manage access, but can be easily used in externally scripted activities or strategy instruction. Additionally, Loll et al., (2010) found that while teachers are optimistic about the capacity of visualizations offered by the digital argumentation diagramming tools to facilitate learning, they also see immediate feedback as essential in unstructured informal learning scenarios. Lightweight social argumentation systems facilitate quicker interaction and feedback, compared to complex multi-task environments that require substantial and time-consuming explicit instructional design, scripting and configuration.

6 Conclusion

Current trends in digital tools for written argumentation seem to be responding either to institutional "learning management" demands for less investment in technical infrastructures and human resources, or instructors' need for versatile lightweight ready to use tools and services that are familiar and aligned with their teaching

[8] Arguman.org was a short-lived open structured social debate platform documented and available for download on GitHub: https://github.com/arguman/arguman.org.

practices. However, Noroozi et al., (2018) argue for the need for more tools that offer second order scaffolding (generalization of strategy adoption for transfer), even though this would seem to imply even more complex and curriculum encompassing systems that go counter to instructors' demands.

With the recent advances in web-based technologies, and text and web analytics technologies (c.f. Part 3 of this book), it is natural that current tool development seems to favour web-based debating or argument analysis environments, for example OVA + , where user inputs can create corpora for research and generation of visualizations or Argdown that uses a markdown coding environment to scaffold and map argumentation. Research focus in the domain of computer-supported argumentation appears to have shifted to defining principles (Benetos, 2017) and strategy instruction (Cotos et al., 2020; Noroozi et al., 2018) that can be combined with simple applications in common use, as well as with analytic approaches to generating representations of writing processes (Vandermeulen et al., 2020).

While we may speculate whether these trends are in reaction to development costs and quickly changing technologies, combined with users' difficulty in appropriating technologies into their writing and teaching practices, they raise questions as to how these shifts in technology development and use redefine the roles relegated to the technology, instructors, and writers/learners.

Innovation in educational technology is often triggered by technological advances but adoption seems susceptible to the hype-curve with effects on practices lagging on the scale of decades if not generations. After a burgeoning from about 1990 to 2010 of digital environments designed for uses within domain-specific or research contexts, few have survived or transitioned to a wider use or use outside their native institution. There is still much research lacking regarding how learners appropriate argumentation tools into their writing processes, moving from such unstructured or open debating environments to constructing written argumentation in academic contexts and how to best support them with this complex activity. As Noroozi et al. (2018) argue, it is also important that writing environments and their tools offer second order scaffolding so writers can more effectively transfer the knowledge gained in learning to argue and write through the use of digital tools into academic skills that are not dependent on a specific tool or system. This raises important questions as to the competencies and literacies instructors and learners must acquire and what strategy instruction is needed to help them navigate through an ever-changing eco-system of digital tools for argumentative writing.

7 List of Tools

See Table 1.

Table 1 Software and platforms reviewed or discussed. In italics are those no longer under development

Tool	Description	Reference and/or URL
Araucaria	Web-based drag-and-drop interface for analysing imported textual arguments. Software development documentation is still available	(Reed & Rowe, 2001), http://araucaria.arg.tech/doku.php
Argdown	MIT Licensed but developed by the Debatelab, Karlsruhe institute of Technology. Argdown offers examples and installation guides and is available for download and installation on local servers. Texts can be edited within Visual Studio Code using the Argdown extension to Markdown code	https://argdown.org/
Arguman.org	An argument analysis and mapping platform, where "users assert contentions to be discussed, supported, proved, or disproved, and argue with premises using because, but, or however conjunctions.". The web-based platform is no longer active, but the code is available for download and installation on any webserver through Github	https://github.com/arguman/arguman.org
ArguMap	A lightweight, strictly mapping mobile app for individual use that allows the grouping and linking of claims with minimal prompts within empty nodes. Maps can be shared with instructors in educator mode	https://appsolutelyfun.com/argumap.html
Argunet	Software for analyzing and visualizing complex debates. Available for download as a client-side application for offline use or as a server-side application for online sharing and collaboration with others on the Argunet server	(Schneider et al., 2007), http://www.argunet.org/,
KIE / Sensemaker (Knowledge Integration Environment)	A platform for integrating multiple sources and diagramming argumentation (Sensemaker) for collaborative debate and knowledge building	(Bell, 2000), http://belvedere.sourceforge.net/
C-SAW	Browser-based authoring tool with built-in contextual aid for developing written argumentation. It was developed using PHP, DOM, XML, and JavaScript and can be run on any server with Apache/MySQL	(Benetos, 2015; Benetos & Betrancourt, 2020), http://tecfa.unige.ch/perso/benetos/C-SAW
Carneades	Diagramming of legal argumentation, using LKIF	(Gordon et al., 2007; T. F. Gordon & Walton, 2006), https://carneades.github.io/
VCRI (Virtual Collaborative Research Institute)	An environment that hosts a suite of tools to support collaborative argumentative writing: co-diagramming, chat, co-writing, textual and graphic debate tools, chat…	(Erkens et al., 2010)
Endoxa Learning	Endoxa Learning is an argumentation diagramming environment that uses critical questions to develop reasoning and learning. It also offers topic lessons with ready-made maps to and teacher dashboard tools	https://endoxalearning.com/

(continued)

Table 1 (continued)

Tool	Description	Reference and/or URL
Euclid	Amongst the first diagramming tools for argumentation and supporting reasoning	(Smolensky et al., 1987)
Kialo, Kialo-edu	Open social debating platform with class management for educators	https://www.kialo.com https://www.kialo-edu.com
OVA +	On line drag-and-drop interface for analysing textual arguments derived from webpages	https://arg-tech.org/index.php/ova/
Rationale	Argument diagramming environment with templates for various argumentation-based genres and built-in scaffolding. Functionalities include resource integration, rating and full text export. Limited free use with web-based with offline mode	(Davies, 2009; van Gelder, 2007), https://www.rationaleonline.com/
Writing Pal (W-Pal)	Intelligent tutoring system for improving reasoning and writing	http://www.adaptiveliteracy.com/writing-pal

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