Belvedere: Stimulating Students' Critical Discussion

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ABSTRACT

We describe "Belvedere," a system to support students engaged in critical discussion of science and public policy issues. The design is intended to address cognitive and metacognitive limitations of unpracticed beginners while supporting their practice of this complex skill. The limitations include (1) difficulty in focusing attention given the abstract and complex nature of theories and arguments, (2) lack of domain knowledge, and (3) lack of motivation. Belvedere addresses these limitations by (1) giving arguments a concrete diagrammatic form, and providing tools for focusing on particular problems encountered in the construction and evaluation of complex arguments; (2) providing access to on-line information resources; and (3) supporting students working in small groups to construct documents to be shared with others. Both prior psychological research and formative evaluation studies with users shaped the interface design.

KEYWORDS: Collaborative Argumentation Environment, Educational Application, Design Rationale.

INTRODUCTION

An early and persistent interest in designing software systems to support argumentation has resulted in interesting work with hypertext systems and with graphical interfaces for argument construction. [1], [3], [6], [7]. For the most part, these systems are designed to provide either a medium for a generic competent reasoner, or support for a specialized expert user in a specific professional practice. For example, Euclid [6] provides a graphical representation language for generic argumentation; gIBIS and JANUS-Argumentation [3] record the process of design in order to support and critique it in accordance with established methods in the design community.

Belvedere aims to support the development of scientific argumentation skills in young students. These students can't be presumed to have either general skills of constructing arguments or the specific knowledge of a domain. Therefore, the design of Belvedere has had to address the cognitive and motivational limitations and requirements of unpracticed beginners, as presented in the psychological literature and as we encountered them in formative testing with 12-15 year olds in a lab study and in 10th grade classrooms in an inner-city public high school. A main goal of our system is to stimulate critical discussion that wouldn't otherwise take place. Our users' final graphical and textual products need not record all their claims and argument moves. We therefore designed Belvedere's representations and functionalities to be used as objects of discussion as well as a medium of discussion.

ADDRESSING STUDENTS' LIMITATIONS

Students have difficulty recognizing abstract relationships implicit in scientific theories and arguments about them. Belvedere uses diagrammatic representations that provide users with concrete forms for diagraming the abstract structure of theories and related arguments. Ideas and relationships are represented as objects (shapes) that can be pointed to, linked to other shapes, and discussed.

Belvedere's diagrams help students identify the overall structure of the argumentation as well as its weaknesses and points where further contributions can be made [6], [7]. Like Euclid, Belvedere uses a box-and-link representation; Belvedere, however, provides a repertory of specialized boxes and links in order to make particular kinds of relations salient to the students and to make the argument relations understandable to the system so that advice can be given.

Students may find it difficult to focus on the important issues in a complex debate. An on-request advisor helps students focus on particular aspects of a complex issue by suggesting ways in which their diagrams can be extended or improved. The advisor offers hints based on principles of maximizing a theory's coverage, consistency, and empirical support. The advisor highlights a single area of the diagram as possibly needing attention. The student can choose whether and how to address the highlighted problem.

Future plans include techniques for collapsing and expanding portions of a diagram, and displaying a complex underlying argument graph under different "viewpoints" designed to highlight certain structural aspects of the controversy.

Students lack the intrinsic motivation of practitioners and students have limited knowledge of most domains, particularly scientific domains. Small-group work and the production of products that will be used by others can provide peer motivation and a sense of authentic activity that teacher- and evaluation-centered work may not provide [2], [4], [5]. To support small group collaboration while allowing each student equal opportunity for input, Belvedere is networked so that students can work concurrently on the same diagram. To supply knowledge resources and allow students to "publish" their work, Belvedere provides facilities for authoring online knowledge resources that can be accessed by students.

Belvedere currently provides additional resources in the form of modest collections of information in several scientific fields that students can access and copy. Future plans include access to the World Wide Web.

SELECTED DESIGN DETAILS

The Display Belvedere is a symbol system for the expression of logical and rhetorical relations between propositions. We wanted users to focus cognitive effort on the relations rather than on learning the program and using it. Thus we made the interface look familiar by using command and icon layouts similar to those of typical drawing programs. We help maintain the students' focus on their understanding of the theories and controversies, rather than on every graphical detail of their diagrams, by automating some of the secondary aspects of the work. For example, graphical shapes are created with a default size, and resize themselves to fit their contents. When an object is moved, its links follow it to retain the logical connection. We decided to strike a balance between the open-ended nature of a drawing program and highly constrained resources of tools for well-structured domains. As a result the interface looks like a drawing program, but using it feels more like assembling circuits and components into desired configurations. Other tools such as the automated advisor provide further relevant functionality not available in drawing programs.

Management of Multiple Applications In our initial studies with students sharing a single machine, some students appeared frustrated when limited to mouse operation while a partner dominated the input. To avoid censorship based on ownership of I/O devices, we design to enable separate machines to display a shared document. Thus each user can modify a shared diagram. Additional functionalities were required to manage this so as to minimize unnecessary redisplay overhead as well as maximize the user's focus on cognitive tasks. Users do not want to be distracted by a constantly changing screen while they are thinking. Also, users must not be able to operate on the same object simultaneously. We therefore "lock" an object as soon as a user starts to use it. When it is locked, other users can't modify it. Nor do they see the object changing: this would be annoying to someone pursuing their own thoughts, as well as involve excess redisplay overhead. When the user is done and releases the lock, a display interrupt is sent to other users' applications. This interrupt is delayed by any applications in which another user is editing, to avoid unexpected change of the context in which the user is working.

CONCLUSIONS

In our work with students, some of the most productive critical discussion appeared to be stimulated by the diagramming activity, yet was not captured in the resulting diagram. Because of this, our current emphasis is on designing representations *the production and inspection of which stimulate critical discussion*, with secondary emphasis on other desiderata, such as formal completeness and sufficient expressiveness to support communication between distant collaborators. This complicates the criteria for interface design, because we must decide when we are designing for conversation embodied *in* the diagrams vs. designing to stimulate *external* conversation that may never be recorded.

Users' discourse processes transcend the representational and computational resources provided by any support software. Thus, the utility of software features should be evaluated in terms of how well they stimulate the right kind of activity in the total human-computer system. We do not assume that local optimization of software support for isolated subtasks (e.g., making "correct" argument diagrams) always optimizes overall task performance. Rather, our main question is: what kind of discourse is facilitated or stimulated by each feature of the interface and of the task posed to the students, and what kind of discourse is inhibited?

ACKNOWLEDGMENTS

This research was conducted while supported by grant MDR-9155715 from the NSF Applications of Advanced Technology program. We also thank Violetta Cavalli-Sforza, John Connelly, Alan Lesgold, and Mike Smith for their valuable input and support.

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