Educational Human-computer Debate: a Computational Dialectics Approach

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Abstract. Theories of learning suggest that dialogue is important in shaping conceptual development. However, there is widespread debate as to the forms of dialogue and which are effective in an educational context. In addressing these issues, we have analysed current knowledge concerning dialectics in philosophy and education. We propose to adopt a computational dialectical approach to study the issues related to the development of an intelligent debating system, which is argued to have potential educational benefit. This approach focuses on using models of dialogue developed in the area of informal logic, which prescribe rules to regulate the evolving dialogue. Our proposed research concerns three main issues in the area of computational dialectics: dialogue model, debating heuristic theory and dialectical relevance.

1 Introduction

The recent development of Computer Based Learning Systems and the emergence of the World Wide Web and the Internet have changed the study life of many people. However, the usual assumption underlying these computer based educational systems is that the computer does all the informing, the student being merely a passive receiver of the information. The type of teaching interaction, that is, may become unduly didactic [13]. There is therefore a need for dialogue within interactive computer systems. Further, theories of learning have long suggested that dialogue has an important role to play in shaping conceptual change and developing reasoning skills [18]. There are many different uses of dialogue in an educational context. For example, Grasso et al.'s [5] "Daphne", a computational agent conducts an advice giving dialogue with the user to provide healthy nutrition education. Maudet and Moore's [10] human computer debate prototype will enable a student and computer to conduct a fair and reasonable debate on a controversial issue. Ravenscroft and Matheson [17] introduce two kinds of asymmetric dialogues to support learning. One is the computer being a "facilitating tutor" and the student the "explainer": the tutor raises some questions, students answer the questions, and the tutor solves the contradictions of the student's commitments and helps the students to reach the correct answer rather than directly tell them. Ravenscroft and Matheson's second dialogue type is similar to the first, but includes further didactic features. Bench-Capon et al. [3] investigated the computer mediated dialogue in legal educational context, which is explanation based, both participants adopting symmetric roles [2]. Pilkington's study of simulation-based learning identified two types of dialogue, an inquiry dialogue with asymmetric roles and a more collaborative game generating cognitive conflict and reflection ([15], [16]). However, there is widespread debate as to the forms of dialogue in general and which are effective in educational contexts in particular. We therefore review two approaches to characterising dialogue types, that of Walton and Krabbe [21] and Baker [1], and then, we make a proposal for human computer debate using a dialectical approach.

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2 Dialogue Typology

2.1 Walton and Krabbe's typology

Type of dialogue	Initial situation	Participant's goal	Goal of dialogue
Persuasion	Conflict of opinion	Persuade other party	Resolve or clarify issue
Inquiry	Needs to have proof	Find and verify evidence	Prove (disprove)
Negotiation	Conflict of interest	Get what you most want	Reasonable settlement that both can live with
Information-seeking	Need information	Acquire or give information	Exchange information
Deliberation	Dilemma or practical choice	Co-ordinate goals and actions	Decide best available course of action
Eristic	Personnel conflict	Verbally hit out at opponent	Reveal deeper basis of conflict

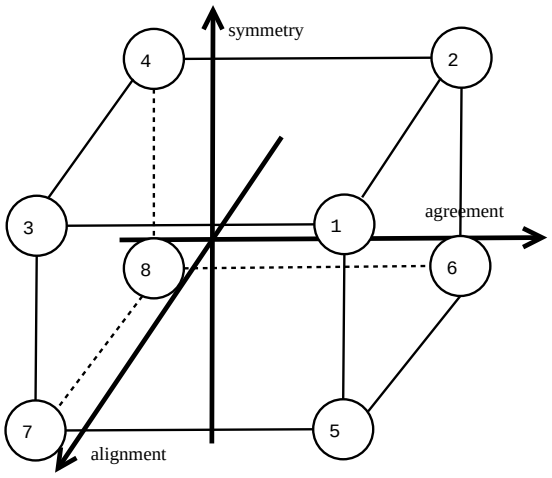
Figure 1. Walton and Krabbe's dialogue typology

The most influential dialogue typology is probably Walton and Krabbe's [21] dialogue model developed in the area of argumentation theory. This model provides a broad typology of dialogue types and their rationale. It is based on three factors: "(i) the initial situation, (ii) the private aims of the participating agent, (iii) the joint aims to which all participants implicitly subscribe". Six dialogue types are included in this model: persuasion, negotiation, inquiry, deliberation, information seeking and eristic. See figure 1 (citing from [21]). Reed examined the above dialogue model in some depth in agent communication research [19]. He suggests that 'eristic' dialogue is unlikely to play a significant role in current computer science research. He also suggests that persuasion, inquiry and information-seeking dialogues handle belief, while negotiation dialogue raises a contract and

deliberation dialogue forms a plan. He further notes that information-seeking dialogue is asymmetric. According to [8], only persuasive, negotiation and eristic dialogue are argumentative, but deliberation, inquiry and information seeking are seen as non-argumentative, although reasoning is believed to occur in all of them.

2.2 Baker's typology

Baker's problem solving model claims that there are eight basic forms of interactions in co-operative problem solving activity in learning situations, see figure 2 (citing from [1] p131).



1. co-construction
2. apparent co-construction
3. co-argumentation
4. apparent co-argumentation
5. acquiescent co-elaboration
6. apparent acquiescent co-elaboration
7. one-side argumentation
8. apparent one-side argumentation

Figure 2. Baker's dialogue model

Baker's model is based on three dimensions: [1] degree of (dis) agreement, [2] degree of (a) symmetry, [3] degree of alignment. Baker's explanation of the degree of (a) symmetry is "either each participant has an alternative proposal, or else one participant simply contests another's proposal" [**?**]. In a computational context, "symmetry" is often taken to suggest that each participant makes more or less equal contributions to the dialogue and follows the same dialogue rules, while "asymmetric" suggests that participants play different roles in dialogue and follow different dialogue rules [10]. For example one participant simply contests or acquiesces to another's proposal [1]. Baker's notion of "alignment" is the same as 'collaborative', which means the desired end goals are the same for both players, while non-collaborative means they do not have identical end goals [10].

Dialogue type	Initial situation	(non)- collaborative	(a) symmetry	Examples
Co-argumentation	conflict	collaborative	symmetric	Negotiation [14], [19]
one-side co-argumentation	conflict	collaborative	asymmetric	Auction or bid
argumentation	conflict	non-collaborative	symmetric	Debate [10] Complex critical discussion [20] Symmetric persuasion [21]
one-side argumentation	conflict	non- collaborative	asymmetric	Asymmetric persuasion [21] Simple critical discussion [20]
co-construction	ignorance	collaborative	symmetric	Deliberation, inquiry [21] Discovery [11]
one-side co-construction	ignorance	collaborative	asymmetric	Facilitating dialogue[18]
information-exchange	ignorance	non- collaborative	symmetric	Information-exchange [6]
Information seeking	ignorance	non- collaborative	asymmetric	Information-seeking [21]

Figure 3. Integrated dialogue typology

2.3 Integration of the two dialogue typologies

Walton and Krabbe's identification focuses on the philosophical study of dialogue, whereas Baker's model is based on co-operative problem solving activity in learning situations. Walton and Krabbe admit the incompleteness of their identification. Actually, some existing educational dialogues are outside Walton and Krabbe's dialogue typology. For example Ravenscroft and Matheson's two kinds of asymmetric dialogues [17], and Pilkington and Mallen's inquiry dialogue with asymmetric roles[16]. Further, in agent communication research, McBurney and Parsons identify two kinds of dialogue: discovery and command dialogue [11], which are outside Walton and Krabbe's dialogue typology [21]. It might be thought that Baker's model is more general and can subsume Walton and Krabbe's. However, some dialogue types can not be distinguished by Baker's model, for example, Walton and Krabbe's deliberation and inquiry dialogues both fall into one category (co-construction dialogue) of Baker's. Therefore, we integrate Walton and Krabbe's and Baker's dialogue typology, form a broad dialogue typology based on initial situation, collaboration and symmetry (i.e., three dimensions).

2.3.1 *Co-argumentation dialogues and one-side co-argumentation dialogue*

Co-argumentation dialogues start from conflict, but both participants' aims are identical, with symmetric roles. Examples such as negotiation can be seen in [19] and [14]. The difference between one-side co-argumentative dialogue and co-argumentative dialogue is that the participants of one-side co-argumentative dialogue adopt asymmetric roles, for example auction or bid. The following dialogue shows an example of a one-side co-argumentative dialogue interaction (B: buyer, S: seller).

B: how much is the Chinese leaf? (information seeking)
S: two pounds.
B: it is too expensive, how about one pound? (negotiation)
S: no, it is not expensive. (unsatisfied with the price)
B: it is raining, if you do not sell, it may go bad, how about 1.2 pound? (active negotiation)
S: no (still unsatisfied).
B: 1.5 pounds? (active toward the deal)
S: ok (deal).

It is worth noting that the buyer and seller adopt different roles in negotiation dialogue, the buyer actively negotiates, while the seller just contests rather than actively negotiates, until the end of the dialogue.

2.3.2 *Argumentation and one-side argumentation dialogue*

Argumentation dialogue starts from conflicts, but both sides attempt to persuade the other to accept their thesis, e.g Maudet and Moore's [10] debating dialogue, Van Eemeren et al.'s [20] complex critical discussion, and Walton and Krabbe's [21] permissive persuasion dialogue (PPD). One-side argumentative dialogue has different roles for both participants, one side builds its position, the other side attacks or contests, e.g Walton and Krabbe's rigorous persuasion dialogue (RPD) [21].

2.3.3 *Co-construction dialogue and one-side co-construction dialogue*

Co-construction dialogue starts from an open problem or question, two participants contribute more or less equally to solve the problem e.g. McBurney and Parsons's [11] discovery dialogue. It is interesting that Walton and Krabbe's [21] deliberation and inquiry dialogue all fall into this category. The participants of one-side co-construction dialogue have different roles, one side provides the solution, the other side may criticise or point out mistakes, but both parties have identical goals to solve the problem e.g. Ravenscroft and Pilkington's [18] facilitating dialogue.

2.3.4 *Information exchange and information seeking dialogue*

Such dialogue does not start from conflict. The participants have different dialogue roles and obligations, one side lacks information, the other side provides information, hence the dialogue is asymmetric in nature (cf. Hamblin's information-oriented dialogue [6]). Given this dialogue typology, our question becomes which of the diverse dialogue types are effective in educational contexts. Answers to this question gained from empirical research have yet been only partial [18]. However, the debating style of dialogue interaction is argued by Maudet and Moore [10] to be important in critical thinking and developing debating and reasoning skills, and also suggested by Pilkington and Mallen's [16] educational discourse analysis to be effective and to have rich educational benefit. A particular concern with our research therefore is to investigate issues surrounding a computer based system for educational debate.

3 A Proposal for Human-Computer Debate

There are at least two main areas of research dealing with dialogue: linguistic discourse analysis and dialectics. The former approach emphasises empirical research into natural language, its structure and processing and concerns actual conversational exchange, but there are well known difficulties in the application of such an intentional account to make dialogue computationally tractable. The latter approach - dialectics - involves a logical account of interaction in terms of rules for particular kinds of responses and interaction, and utilises "Dialogue Game Theory" models developed within the field of Informal Logic to prescribe how dialogue should be regulated. There is an increasing use of a computational dialectics approach in the area of human computer interaction (e.g. [5]), agent communication (e. g. [7]), mediation of legal reasoning (e. g. [2]) and Artificial Intelligence in general [22]. In some literature, computational dialectics is seen as a new sub-field of Artificial Intelligence [4]. There are, however, many open research issues within computational dialectics, and an investigation of what are believed to be the most important in adopting the computational dialectical approach to develop a human computer debating system will form the basis of this research. Previous research in this application area ([12], [10]) has revealed several important issues that need further investigation.

3.1 Dialogue model

The most important issue concerns the choice or development of a suitable dialectical model. This is fundamental, because it forms the dialogue model that the computer system will use to rule as to the acceptability of user input and to delineate possible dialogue contributions it can make. The dialogue model is therefore the fundamental element underlying the proposed computer debate system. There are however many normative dialogue game systems that have been proposed in the area of informal logic and dialectics [10]. It is necessary therefore to select or develop a suitable dialectical model given the pre-requisites for a competitive human-computer debate on controversial issues such as capital punishment. Next, the appropriateness of the dialectical model needs to be established. The proposed experimental work required for this, aimed at iteratively building a computational realisation of the model and establishing whether the model can be readily assimilated and used to generate good discourse, will form part of the unique contribution of this research. It is anticipated that this part of the work will contribute towards developments in human computer dialogue and also help to illuminate research issues in the field of dialectic itself.

3.2 Debating strategic heuristics

In dialectical systems, the dialogue regulations usually leave some room for choices as to permissible move type and substantive content [12]. It is crucial therefore that the computer has some means of selecting between the available possibilities. This choice must be based on some suitable strategy, and the research will therefore seek

to develop a theory of debating heuristics usable by the debating system. A dialogue strategy is a set of moves designed to cumulate in the achievement of one's objective in the dialogue game. A strategic heuristic in a dialogue game can be seen as a decision about what to do next and may involve forms of argument such as argument from analogy, argument from popularity and argument from consequence. Suitable computational strategies are currently not known, but are essential if the computer is to produce high quality dialogue contributions. To determine the appropriateness of strategies generated by the theory, further technical and user studies will be required, aimed at testing whether the strategy is effective. Analysis of results will illuminate the theory of debating heuristics and hence make a major contribution to the field of computational dialectics.

3.3 Dialectical relevance

A related problem for dialectical systems is that no rule actually controls the relevance of the dialogue moves [9]. Without relevance rules to govern the dialogue, however, it may lose focus, e.g. if the student inputs an irrelevant move, then a computer system without a relevance ruling will follow the student into an irrelevant dialogue. Given the importance of relevance in dialectical system, existing literature concerning the notion of relevance (e. g. [23]) will be investigated and used to derive relevance measures for use within the computer debating system. Further experimental work will then be conducted, aimed at testing the effectiveness of the proposed measures. The research will therefore contribute to our knowledge of how to create more useful dialectical models.

4 Conclusion

We have reviewed two key philosophical and educational dialogue typologies, proposed a broad dialogue typology and argued that debating style dialogue is potentially effective in critical thinking and development of student's debating skills (cf. [12], [16]). A proposal is made to research issues in building an intelligent debating system using a computational dialectical approach. Three important issues are discussed and proposed for further research.

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