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Deliberation, Practical Reasoning and Problem-solving

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Abstract: We present a series of realistic examples of deliberation and discuss how they can form the basis for building a typology of deliberation dialogues. The observations from our examples are used to suggest that argumentation researchers and philosophers have been thinking about deliberation in overly simplistic ways. We argue that to include all the kinds of argumentation that make up realistic deliberations, it is necessary to distinguish between different kinds of deliberations. We propose a model including a problem-solving type of deliberation based on practical reasoning, characterised by revisions of the initial issue made necessary by the agents' increased knowledge of new circumstances.

Keywords: Deliberation dialogue, typology of deliberation, computational model, *stasis*, changing the issue

1. Introduction

In this paper, we present a series of realistic examples of deliberation and discuss how they can form the basis for building a typology of deliberation dialogues. We build upon models of deliberation dialogue in Artificial Intelligence, including the McBurney, Hitchcock and Parsons model (McBurney et al., 2007), and a computational model that recently arose from this literature. We present a series of realistic examples of deliberation and discuss how they can form the basis for building a typology of deliberation dialogues. The observations from our examples are used to suggest that argumentation researchers and philosophers have been thinking about deliberation in overly simplistic ways. We argue that to include all the kinds of argumentation that make up realistic deliberations, it is necessary to distinguish between different kinds of deliberations.

We show that while many deliberations have the aim of making a choice between objectives fixed at the outset, others are on how to do something that requires action because a problem has arisen. We approach problem-solving deliberation on how to do something using the scheme for practical reasoning, and contrast it with the deliberation of the dilemma kind often emphasized in Philosophy. To develop more comprehensive computational models of problem-solving deliberation, further characteristics must be modelled such as how to revise the opening issue and how the introduction of new information influences the identification and choice of new actions. In our previous research (Walton et al., 2014), we have introduced the idea of extending the McBurney, Hitchcock and Parsons (MHP) model, to include the possibility of considering an open knowledge base, that allows participants to record the changes of

circumstances during deliberation. In this research, we reflect on existing deliberation models, and we argue that the need of additional elements in the MHP model is necessary to especially represent the problem-solving type of deliberation. The differentiation between types of deliberation then represents a context for the initial findings presented in Walton et al. (2014). Here we go further, and through the use of examples, we analyse the characteristics that form our typology of deliberative dialogue, in particular distinguishing between problem-solving and the dilemma kind of deliberation, and we present an initial account of how these features may be represented within computational frameworks.

2. Status and deliberation

In the standard models of persuasion dialogue currently accepted in argumentation, there are three stages: an opening stage, an argumentation stage, and a closing stage. The so-called issue or conflict of opinions is set in place at the opening stage, and then the arguments on both sides go back and forth during the argumentation stage. At the closing stage it is decided which side had the strongest supporting arguments for or against the issue. The same model applies in legal argumentation in a trial. The so-called burden of persuasion is set at the opening stage by law, and then during the argumentation stage as both sides put forward their arguments, there is an evidential burden that can shift from one side to the other. The outcome is decided at the closing stage depending on which side is taken by the judge to have met its burden of persuasion.

In the ancient manuals on rhetoric, this approach was called the *stasis theory*. The so-called *stasis* (or *status*, as it is called in Latin) is the issue set in place at the opening stage of a speech, and the rest of the speech is confined to pro and con arguments that are relevant to showing whether this designated proposition is true or false. Setting the *status* in place at the opening stage has normative implications that apply during the argumentation stage. Suppose it can be shown that what one of the arguer says wanders away from the topic and moves onto some other distracting or emotionally exciting matter that is irrelevant to proving whether the *status* proposition at issue is true or false. In such a case, a valid normative criticism would be that this line of argument is irrelevant. Relevance, just as in law, can be described as a failure of an argument to carry sufficient probative weight to either prove or disprove the proposition at issue, as determined by the *status*.

In the standard models of deliberation dialogue accepted widely in the computational argumentation literature, deliberation is different from persuasion dialogue but also similar to it in some respects. One difference is that the issue to be resolved in deliberation dialogue is not whether a designated proposition is true or false, as it is in persuasion dialogue. Instead, the issue is one that confronts an agent in a particular set of circumstances where choice is required. A typical deliberation of this sort often emphasized in the Philosophy literature concerns a dilemma, a two-place issue, such as the decision whether physician-assisted suicide should be legally permitted or not in a jurisdiction.

The *stasis* principle also appears to apply to certain kinds of debates that are widely studied by the speech communication community. In this category are cases of deliberation by members of large groups, such as national or state legislatures, city councils, school boards or University Senate meetings. In such cases, the argumentation has the form of a debate. Typically, a proposal on what to do or policy has been put forward, and participants can put forward arguments pro or con the proposal or policy. Debates of this kind feature advocacy arguments by both sides. There is typically a moderator, speaker or chairperson whose job is to see to it that the

arguers follow some set of procedural rules, such as Robert's Rules of Order.¹ The arguments are required to stick closely to the specifics of the proposal being discussed, and the moderator may invoke a relevance rule requiring the members taking part in the debate to speak to the motion. If a motion has been defeated, it is allowable to make a new motion.

Deliberations of this kind can be categorized as debates, meaning that there is a third party, a judge or moderator who decides which side has won the argument, and of course in many instances a show of hands will be taken, and a decision is made by majority vote. Research on discourse analysis of deliberative debates goes as far as defining measurements for deliberative quality, presenting interesting insights on criteria for evaluating a deliberation outcome (Steenbergen et al. 2003). In this paper, however, we are interested in relatively small group deliberations that generally do not involve the structure and complexity of political debates, and are less adversarial. More complex political debates seem to be a blend of deliberation and persuasion dialogue.

One similarity between the standard approach to deliberation dialogue and persuasion dialogue is that in both types of dialogue the issue is set at the opening stage, stays in place during the argumentation stage, and is used to determine at the closing stage which side was victorious. The sharing of the fixed *status* property, however, seems to become open to questioning on some models of deliberation. By examining different examples, in this paper, we show that the *status* property may be subject to changes during the deliberation and we argue that models of deliberation should account for such a revision.

On the formal argumentation model of deliberation proposed by Walton et al. (2014), a strong emphasis is placed on the importance in a rational deliberation procedure of the participants taking the changing circumstances of the case into account. The argument for moving to this theory is that it should be a central characteristic of any normative model of deliberation that the procedure should be flexible during the argumentation stage. Plans that may have previously been set in place can then be quickly modified to adapt to the necessities of new circumstances in a volatile case subject to rapid changes.

An implication of this approach suggests that the choices that are set in place at the initial stage of deliberation may be changing as the dialogue moves forward and participants become aware of new or revised circumstances. Suppose that an agent or a group of agents is making a decision in a typical dilemma case where there is only a choice between two options. Later on, suppose that new information comes in because of observations of changing circumstances. At this point there is no possibility to account for how to deal with the situation in which this new information indicates that there is a third option to be considered that was not present before. For example, suppose that we are making a decision on what flavor of gelato to buy, but in the shop where we are about to make the choice, all the containers of gelato displayed are empty except for one containing chocolate gelato and another containing vanilla gelato. Just as we are about to decide, the owner of the shop brings in a new container of gelato containing cherry gelato, opens it, and puts it in the display case alongside the other two containers. With these changing circumstances being observed by the agent making the choice, a third option becomes available to the agents. The status that was set in place in the first instance has changed, so that now a choice needs to be made between three options. This may also happen the other way around, for example in a case where there were originally three types of gelato available, but one was

¹ This type of deliberation was analyzed by J. Anthony Blair in a CRRAR talk *Advocacy vs. Inquiry in Small-Group Deliberations* at the ECA Conference in 2015 (Blair 2015).

emptied by previous consumers while we are making the decision, reducing the choice to a decision between two flavors.

This case is a very simple example for illustrative purposes, but it would seem that the same principle applies to much more complex deliberations, where for example different participants exchange information of individual intentions to perform certain actions that were not previously known by the other participants. Another example is the investment in a stock market, where significant changes are made rapidly in the choice to be made. In general, it is problematic to deal with realistic deliberations in which agents may be asked to make a decision between two options but then an investigation of the circumstances of the case highlights other relevant options that might even be better than the original options. There is even a traditional informal fallacy associated with this kind of problem called the black-and-white fallacy, the fallacy of reducing a complex decision where there should be a range of options considered to a simplistic yes-no formulation of the question to be decided.

These considerations suggest that there is a key difference between persuasion and deliberation dialogue that has not been previously noticed. In persuasion dialogue, the original *status* set in place at the opening stage remains fixed through the argumentation stage in order to make the arguers stay on point. In deliberation dialogue however, because of the vital need for flexibility, a formulation of the issue needs to be made that is variable during the argumentation stage so that options can be added to it, or deleted from it, as relevant circumstances change. This suggests also that relevance needs to be defined in a different way in deliberation dialogue from the widely accepted way it has been viewed in persuasion dialogue.

3. Case studies of problem-solving deliberation

In this section, we provide a set of examples that show differences in the kind of deliberation dialogue that participants are involved. This forms a basis to highlight how existing argumentation-based deliberation models require further refinements and additional characteristics to better represent more realistic deliberations.

3.1. The printer example

In this case, Brian had a problem with his printer (Walton et al. 2014, pp. 6-7; Walton 2015, pp. 149-153). Whenever he scanned a document using the automatic document feeder, a black line appeared down the middle of the page. Brian considered sending it back to the manufacturer, but that might mean remaining a long time with no printer. Brian decided to try to fix it himself. Following the instructions in the troubleshooting guide, he opened the scanner cover and located a small strip of glass with a plastic cover at the left of the glass. He peeled the plastic cover off and found a small black mark in the middle of it. Using a soft cleaning pad, Brian managed to remove the black mark. He reapplied the plastic cover to the strip of glass and tried to scan a document. He then found that there was no black line down the middle of the page.

The printer example represents a situation in which the deliberation is about solving a problem. Many deliberations are not on what to do, given a choice between several options, but on how to do something, something that requires action because a problem has arisen. In the printer example, the scanner is not working properly, and cannot be used in its present state because of the black line down the middle of the page. So something has to be done. The deliberation in this situation is between the option of trying to fix it and sending it back to the

manufacturer. The deliberation may also be considered as posing a problem that needs to be solved as represented in Figure 1.

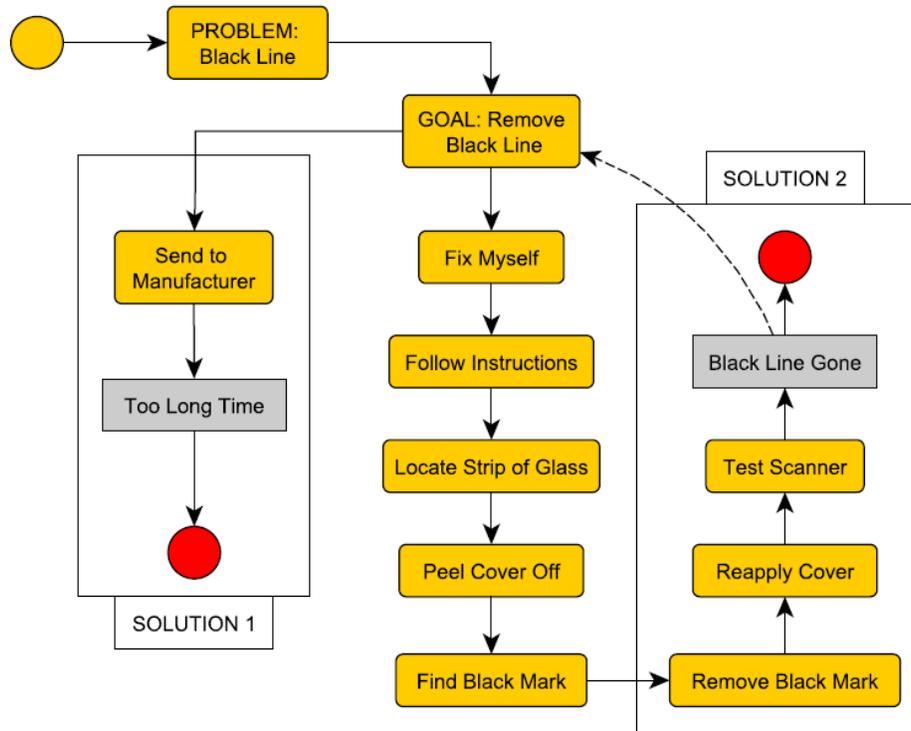


Figure 1: Problem Solving in the Printer Example

This case indicates how the problem-solving kind of deliberation is based on one particular argumentation scheme that is fundamentally important above all the others, and that is the *scheme for practical reasoning*. Practical reasoning is sometimes a purely instrumental form of argumentation in which the circumstances pose some sort of practical problem, such as fixing a printer, and means for solving the problem are sought. However, in other instances, values are involved as well as factual matters, and so it is generally assumed in the current literature that the value-based version of practical reasoning represents a more general form of practical reasoning. Values can be ignored if the case is one that requires only considering only how to find a means to fulfill a goal without considering the values of the agents. The argumentation scheme for value-based practical reasoning (Bench-Capon, 2003) is presented below.

VALUE-BASED PRACTICAL REASONING

Premise 1: I have a goal G.
 Premise 2: G is supported by my set of values, V.
 Premise 3: Bringing about A is necessary (or sufficient) for me to bring about G.
 Conclusion: Therefore, I should (practically ought to) bring about A.

Critical Questions:

CQ1: What other goals do I have that might conflict with G?
 CQ2: How well is G supported by (or at least consistent with) my values V?

- CQ3: What alternative actions to my bringing about A that would also bring about G should be considered?
- CQ4: Among bringing about A and these alternative actions, which is arguably the best of the whole set, in light of considerations of efficiency in bringing about G?
- CQ5: Among bringing about A and these alternative actions, which is arguably the best of the whole set, in light of my values V?
- CQ6: What grounds are there for arguing that it is practically possible for me to bring about A?
- CQ7: What consequences of my bringing about A that might have even greater negative value than the positive value of G should be taken into account?

With the broken printer example, we have shown an example of *Problem-Solving Deliberation*. Generally, the argumentation scheme for practical reasoning is able to represent the posing of the initial issue as a goal. The critical questions CQ1 and CQ2, that question whether there are other goals or whether the goal is worthy to be pursued, may be used to enter a phase of revision of the initial issue. For example, if Solution 2 was not leading to a positive outcome, Brian may decide that there is no point in fixing the printer and change the goal to buying a new printer. However, while the practical reasoning scheme is largely used in the computational community, the difference highlighted by this example lies in when this scheme is instantiated. Here we could have a scheme representing Solution 1, and only after that is refused, Brian elaborates Solution 2. This contrasts with, for example, the use of this practical reasoning scheme in models such as that of Black and Atkinson (2009) in which it is assumed that Solution 1 and Solution 2 are known by the agents since the beginning. Although in the printer example we may also accept that both options will be elaborated from the initial stage, there are other examples, such as our next case study, in which an alternative cannot be elaborated in advance as the circumstances for finding alternative solutions are not known at the outset.

In the next section, we move on to present and discuss some other examples that are instances of deliberation and are based on practical reasoning used to try to find a solution to a problem.

3.2. The disaster example

Two agents x , a local authority and y , a humanitarian organization, are concerned with the repair of the water supply in a location that has suffered catastrophic damage. Agent x proposes to stop the water supply to the location. Agent y argues that there is a need for water in that location to run a field hospital, which is required to aid disaster victims. Agent x proposes that the supply of water to the location must be stopped because it is not safe since the water may be contaminated due to excavators in use at that time. To solve the problem, x and y need to modify their individual plans, constrained by their goals, the known circumstances of the case, and values such as public safety.

The example summarized above is part of a larger example (Toniolo, 2013). The example clearly involves practical reasoning, because each organization has its goals, and is compelled to act in accord with these goals, given the circumstances and the means available. Several solutions to address conflicts are discussed in Toniolo (2013). For example, the field hospital might be set up in a different location where there is no danger of water contamination. One of the water supply sources might only be used when arrangements can be made for the excavators not to be in use during periods when water is available. Each side needs to build its plan in consultation with planning of the other side. Conflicts of this sort need to be identified for good

planning, and to be resolved or dealt with by arguments put forward by each side in collective deliberations.

Within the larger example, an instance of dialogue involving two incompatible courses of action, something has to be done one way or the other, and the issue concerns public safety. Moreover, each side has arguments to back up their position. In particular, the deliberation involves a decision between putting a water line to the field hospital site or not. But the problem, when expressed this way, may be misrepresented as simply one of putting the water line there or not. It is really a problem of how to deal with the conflict between the needs of the two agents. Agents engage in deliberative dialogue and attempt to solve conflicts by modifying individual plans to accommodate other agents' constraints. The information shared about individual plans is fundamental to derive the identification of alternative courses of actions, and as for the printer example, alternatives are formed after a solution, or a part of it may be considered unsatisfactory to solve the problem. These new alternatives are still considered relevant as the deliberation proceeds, as they are formed in light of the discovery of conflicts or changes in the circumstances and they contribute to the issue of how to solve the problem rather than the decision of whether or not the agents should perform an action.

This example and the one discussed above suggests that we may have been misled in the argumentation field into thinking about deliberation as always representing a choice between two or more fixed options set at the opening stage of the dialogue. This seems natural to us, perhaps because it is similar to the persuasion dialogue model, with a thesis to be proved or disproved is set in place at the opening stage, remains fixed during the argumentation stage, and determines how the argumentation is evaluated at the closing stage. We also tend to emphasize the kind of deliberation called a dilemma, much written about in Philosophy, where there is a hard choice between two opposed options.

A distinction could be drawn between a deliberation on how to do something, and a deliberation of the dilemma kind, where the option of slipping between the horns of the dilemma looking for other solutions to the problem does not appear to be available. This observation suggests that we have been thinking about deliberation in a way that is too simplistic to include all the kinds of things that go on in deliberations, and to be more realistic about it, we need to distinguish between different kinds of deliberations.

3.3. The private schools example

This example, a one-page article in *The Economist* (August 1, 2015, p. 9) poses a problem by describing a given situation, and offers advice on how to solve the problem. The advice is based on weighing pro and con arguments. The given situation is described as follows:

Education in most of the developing world is shocking. Half of children in South Asia and a third of those in Africa who complete four years of schooling cannot read properly. In India 60% of 6 to 14-year-olds cannot read at the level of a child who has finished two years of schooling.

The article discusses two potential solutions to the problem: government schools and private education. The article then makes a number of factual statements, backed up by statistical claims, leading to the conclusion that government education has failed:

In a survey of rural Indian schools, a quarter of teachers were absent. In Africa the World Bank found teacher-absenteeism rates of 15-25%. Pakistan recently discovered that it had over 8,000 nonexistent state schools, 17% of the total. Sierra Leone spotted 6,000 ‘ghost teachers’, nearly a fifth the number on the state payroll.

The article continues to state that part of the problem is the powerful teachers’ unions who see the jobs as sinecures, and the state education budget as a revenue stream. The article states that for these reasons, and with the growth of the economy and jobs requiring education, there has been a boom in private schools. Since the unions are fearsome enemies, the governments leave them to run the schools.

This case is not a straightforward instance of deliberation dialogue, because *The Economist*, or at least the author of the article who wrote it for *The Economist* is not in a position to make the decision for private or public education, one way or the other.

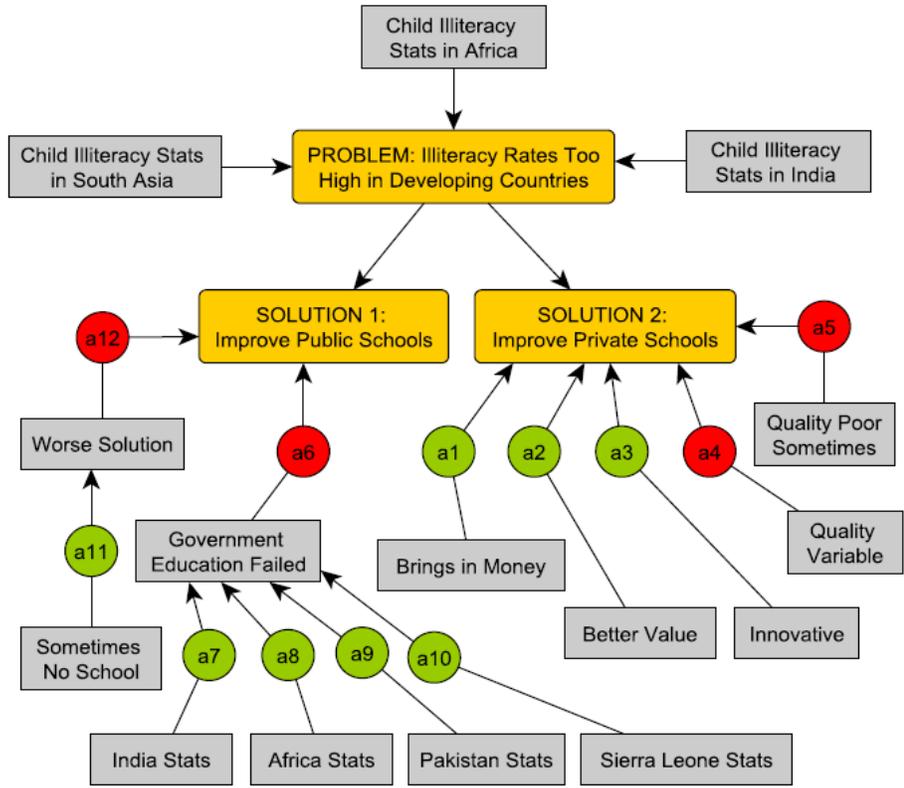


Figure 2: Argument Map of the Education Example

It is an instance of advising dialogue, where one party offers advice to the other about a problem faced by the second party (Grasso 2015). The advising party enters into the deliberation, examines the pros and cons on both sides, and presents a solution that can be used by the other parties making the decision. This form of article is common in *The Economist*, in cases where the problem is to a significant extent one of economics. The advisor can collect the relevant facts as statistical findings that bear on the problem.

The article presents three arguments to support the furthering of private education as a solution to the problem, as represented in Figure 2. First, it brings in money, not only from parents but also from investors. Second, private schools are often better value for money than state schools. Third, private schools are innovative, because they use computer technology to provide teaching materials linked to a central system that can monitor work. These arguments are shown in Figure 2 as arguments *a1*, *a2* and *a3*. Pro arguments are shown in green circular nodes. Con arguments are shown in red circular nodes for a total of twelve arguments.

The article does not just consider arguments for the private school solution to the problem. It also cites some arguments of critics of the private school solution. Critics argue that the quality of private teaching is variable, and sometimes poor. As a counter to this argument the article states that private school is better as an alternative than public school, which is a worse solution because it sometimes means no school at all. In conclusion, the article offers the advice that government should therefore be asking how to boost private education, instead of discouraging it. The action proposed is that governments should either subsidize private schools, or at least stop trying to block their attempts to move forward.

More importantly, the argumentation in this example represents a highly typical use of practical reasoning to offer advice in deliberations on how to solve a problem. First, the problem is described by setting out factual and statistical assertions that described an existing

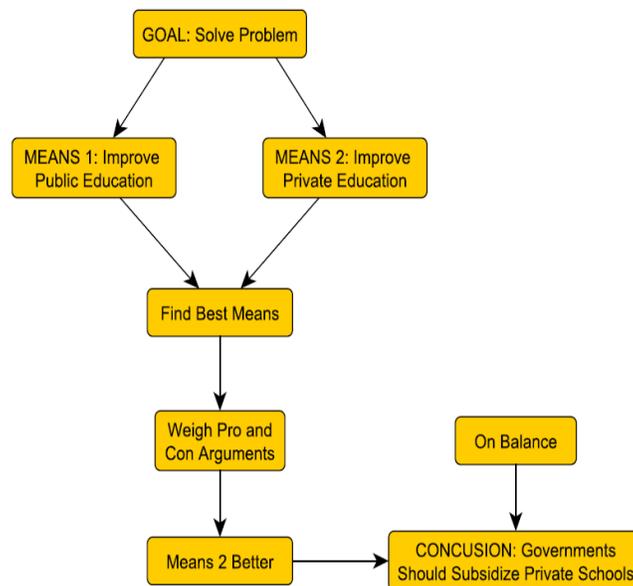


Figure 3: Practical Reasoning in the Education Example

situation. Second, alternative solutions to the problem are discussed and arguments are brought forward as arguments pro and con each proposed solution are presented. On balance, one proposed solution comes out to be the best one, and on this basis the sequence of argumentation going through the twelve arguments shown in Figure 2 concludes that this solution should be taken up as the recommended course of action. Figure 3 shows how, in general outline, the procedure works in this example. The way the deliberation process is set out is shown as a sequence of practical reasoning. The goal is to solve the problem, and various means of moving forward towards solving the problem are discussed.

In this instance, two means of solving the problem are discussed, improving public education or improving private education. The discussion moves forward by bringing forward arguments about which is the better of the alternative means. The next part of the procedure is a typical argumentation interval in which pro and con arguments are put forward supporting or attacking each means that is postulated.

The circumstances pose a problem that needs to be solved. The means are to improve teaching. But the problem is how to do that. Two alternative courses of action are considered, improving public the (state) school system or improving the private schools. Arguments pro and con both options are considered. Through a sequence of argumentation of the kind shown in Figure 2, a finding is arrived at that the one course of action is better than the other.

3.4. The example of buying a car

A good test for any theory of deliberation is the example of deciding which car to buy. Suppose Mary and Bob have decided that their car which they have had for ten years has become too costly to maintain and requires a complete overhaul, and so they decide that it would be better to buy a new car. Mary prefers the Volvo while Bob prefer the Porsche. They discuss which would be the better choice. She argues that the Volvo is safer. Bob argues that the Porsche is more sporty. This discussion goes on for a while considering pros and cons of these two cars with seven argument being presented. But then they discover the car buying guide of *Consumer Reports*, which offers some relevant information about frequency of repair records and the outcomes of crash testing.

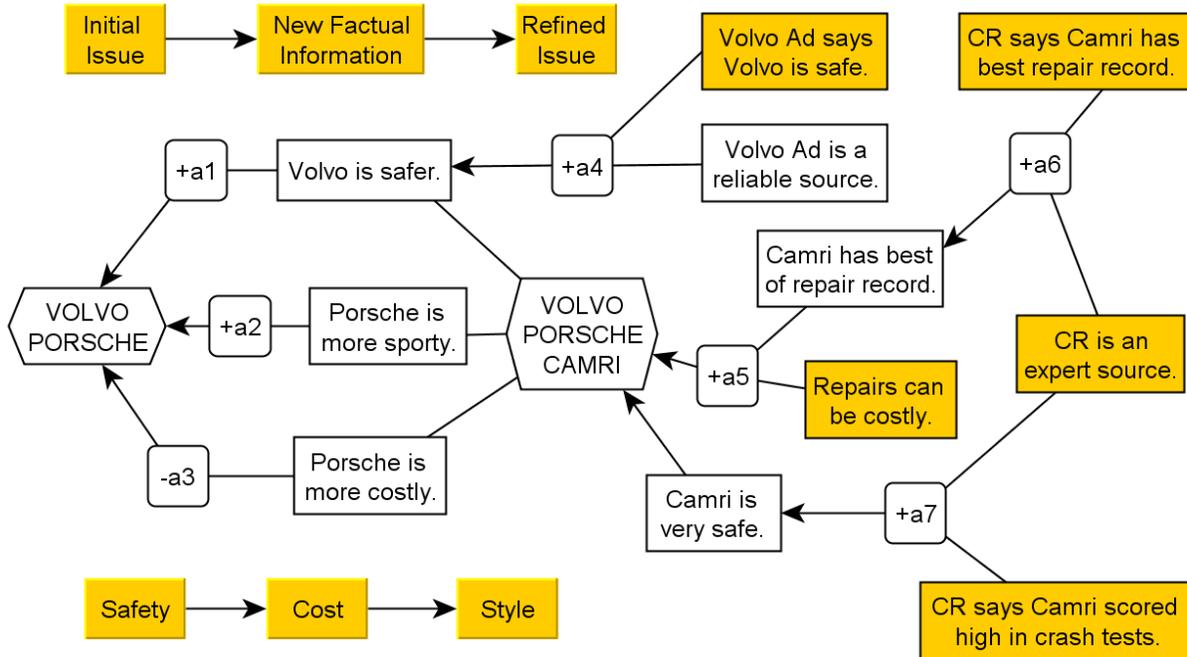


Figure 4: Issues in the Car Buying Example

Bob and Mary share several values that are important for making their decision: safety, costs and style. If we were to put these values in a priority ordering, safety would be at the top for Mary, while style would be at the top for Bob. But both think that cost is also important. In some AI argumentation systems, weights are attached to these values for each party, but here we keep the example simple for purposes of illustration. There is also another argument to be considered, a4, that has come forward because both Bob and Mary have seen numerous Volvo ads claiming that the Volvo is a very safe car. This provides an argument that supports Mary's claim that the Volvo is safer.

When the deliberation began, at the opening stage, as shown in the six-sided box at the left, the issue for Bob and Mary is whether they should buy a Volvo or a Porsche. On the left side, the two nodes labeled a1 and a2 are shown as pro arguments, as indicated by the plus sign. But a third argument is also presented. Both know that the Porsche is more costly, and this constitutes a con argument against the Porsche for both of them, because they share the value of saving costs.

It is at this point where the new information comes in from the *Consumer Reports* car buying guide. They find in the buying guide that the Camry has the best frequency of repair record, and since both know from experience that repairs to a car can be costly, a new argument a5 has become relevant that supports the Camry. Mary and Bob also find out from reading the car buying guide that the Camry scored high in the latest crash tests. This is important to their deliberations because it suggests that the Camry is very safe.

Clearly Mary and Bob have to take this new information into account. At a particular point in the deliberation point they collected some facts that are relevant to their decision, and these facts, along with the discussions they have about them, reconfigures the deliberation. It is no longer simply an issue between buying a Volvo or buying a Porsche, as shown in the six-sided box at the left. It is now an issue about whether they should buy a Volvo, a Porsche or a Camry, as shown in the six-sided box in the middle of Figure 4. The sequence leading to the refinement of the issue is shown in the three boxes with borders at the top left of Figure 4.

This deliberation started out as a choice between two cars followed by a sequence of argumentation in which the pros and cons of each option are considered. But then, as more information came in about the situation, the original decision to be made was reconfigured. At this point it was seen that the options needed to be re-evaluated. The revision of the issue informed by the information and discussion shared during the dialogue led to the identification of new relevant alternatives for restructuring the deliberation.

There are formal and computational argumentation systems that allow for the refinement of the initial issue in a deliberation by allowing incoming information to enable the participants to reformulate the issue. For example, version 4 (<http://carneades.github.io/>) of the Carneades argumentation system (CAS) has this capability. The structure of the argumentation in Figure 4 is in fact recognizable as a simplified version of the way CAS evaluates argumentation using practical reasoning and pro-con argumentation.

3.5. The example of collaborative design and construction

An interesting example of deliberative dialogue is that of collaborative design. This topic is relevant in our paper as the focus of the dialogue is to solve a problem, where different designers have to collaboratively create a new object by considering some initial requirements. There are numerous studies of early stage collaborative design activities according to the different subjects

of design, which may range from engineering, the built environment, informatics and so on. Generally, these studies share the common objective of understanding the cognitive process of designers while they explore alternatives for new products. Generally, these types of studies involve initial observation of individuals in teams, discourse analysis through transcripts and video recordings, and definition of a protocol that may be employed to support these activities more effectively. As discussed in Stumpf and McDonnell (2002), the interaction between teams in early design activities involves an argumentation process. Aakhus and Jackson (2005) study the design process of a device as a paradigm to inform a theory for design and support communication and interaction. In this paper, we are also interested in the type of dialogue that occurs between designers. The phase of design that focusses on the identification of the product is a deliberative dialogue underpinned by practical reasoning as it involves the decision of what to do to realise the idea (Leon and Toniolo 2015). The dialogue presents a record of the process of design, therefore it represents an example of how participants move forward to solve a problem. In particular, these dialogues have no initial set of options: alternatives are formed and discussed, accepted, refuted or reconsidered while the dialogue takes place.

Here we present an interpretation of a dialogue in which two designers, Mark and Jane, aim to design a litter-disposal system for the passenger compartment in a railway train. The objective of the system is to be both convenient for the passengers to deposit garbage and easy for the cleaners to collect the garbage. This is an interpretation of a transcript of the design process from a collection of tasks in Yao (2007).

Mark: Where should we put the bin? We can put it under the table.

Jane: But it will affect the movement of the passengers' legs.

Mark: We need to consider that it needs to be easy for the cleaners to pick up the rubbish. And cleaners walk along the corridor.

Jane: We could put it under the seats.

Mark: Under the seat is not convenient for being picked up as the passenger would have to move away, we could put it along the aisle beside the chairs.

--- Drawing of bins beside chairs

Jane: Is beside the chairs a good place? How would the bin collect the rubbish? We can have a bag or just a bucket to be emptied.

Mark: I prefer to have bags because if we have a bucket it will take too long to be cleaned.

Jane: How would we open it for collecting the rubbish?

Mark: We can open it from the front or from the side.

Jane: If it opens from the front it will be good for the cleaners to pick it up, if it opens from the passenger sitting beside the bin would have to move to let other people put the rubbish in.

Mark: In both cases the bin is too close to the passengers for the cleaners to pick it up, it will be disgusting.

--- New customer requirement: the number of units should be limited

Mark: None of the three positions will be useful, as there will be too many units to be installed.

Jane: This is making me think that we should have an automatic system that packages and collects the rubbish instead of manual.

Mark: In a train a bin is used for peel, paper... not big items. We can design a small bin.

Jane: If it is small, we should place the bin under the window in a way that opens from the top.

B: Is there enough space?

A: Yes, there is, we can hide it inside the wall and the collection will be automatic.

Here we omit the rest of the dialogue, in which the system is then designed with bins under the window and bags with plastic zippers fixed on a conveyor belt that passes through the whole compartment, and shift every time a bin is used; when a bag is full it gets replaced.

In this dialogue we can observe that there are a number of subtasks to be solved, such as where the bin is placed, how it should be shaped, and how rubbish should be stored and collected. All of them are interrelated, and information about one subtask informs a solution for a different subtask. Let us focus on where should we place the bin; in Figure 5 we show the arguments for the identification of different alternatives. In the initial part of the dialogue, three options are formulated, where each of them is formed after another is deemed not acceptable. The last option (along the aisle) is challenged by Jane but remains an open alternative until Mark dismisses all the three with the two arguments. Mark also shares some information about the behavior of the cleaners that informs Jane's option for positioning it under the seats. A fourth position is considered, also informed by some information about the usage of bins in the train, and finally this is the one chosen.

As for the examples that we have previously presented, there is a problem to be solved for which a number of options is formulated. Differently from the car example, here the new options are combinations of options, such as having a bin in four different positions each of those with or without bags, and that may open from top or the side. Similar to the car example, the new options are guided by the new information shared during the dialogue which may for example come from an information-seeking process (such as the type of rubbish used). Similarly, since new information may come from a change of circumstances, in this case we have an additional requirement that eliminates all the existing alternatives.

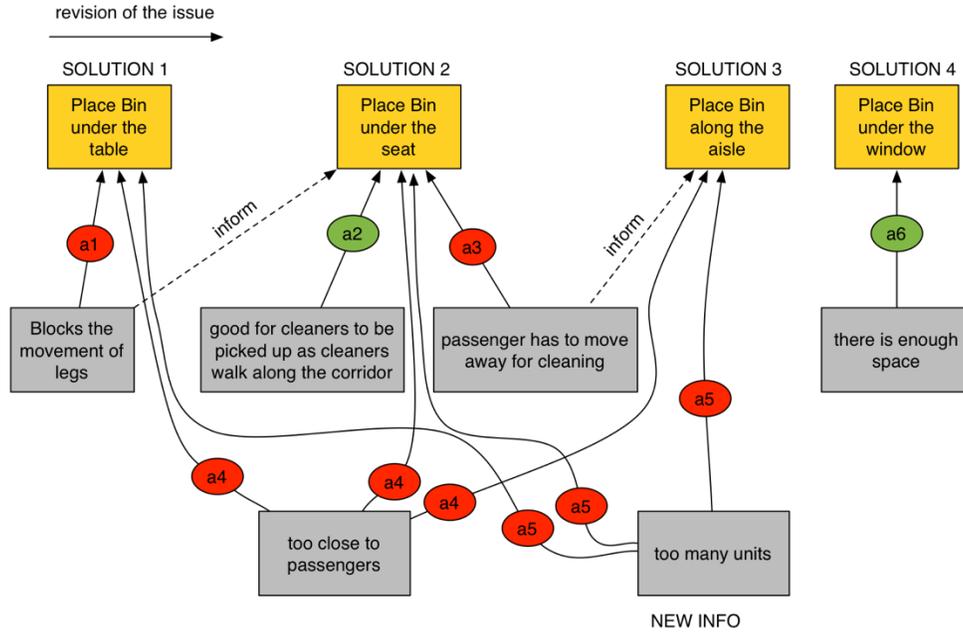


Figure 5: Revision of position of the bins

In this section, we have presented a number of case studies, where we have shown that there exists a type of deliberation called problem-solving deliberation in which there is an initial problem to be solved. The initial issue states a number of options, a number of alternatives that agents are expected to deliberate upon, but this issue may be revised during deliberation according to new information or changes of circumstances. The revised alternatives are identified, guided by information pro or con, for existing alternatives and they are considered relevant as long as they provide a general or partial solution to the initial problem. The issue itself may also be dropped if the circumstances of the problem are no longer verified. In the next section, we consider existing computational models of deliberation dialogue and discuss what general characteristics are still required in light of the analysis of the above examples.

4. Computational models of problem-solving deliberation

In this paper, we argue that although deliberation has often been modelled as a decision on whether to do something or not, there are some other forms of deliberation that must be considered. In Artificial Intelligence, this is especially important as it influences the way deliberation dialogue models are developed and it changes the way a system may be designed. Computational models of dialogue that have been designed for deliberation include protocols that are influenced by the seminal work of McBurney et al. (2007) and underpinned by a computational representation of the value-based practical reasoning scheme presented in Section 3.1 (Atkinson 2005; Atkinson and Bench-Capon 2007). In Atkinson (2005), an example is used of a deliberation on whether UK should go to war with Iraq. This is the kind of deliberation that maintains status unchanged (should we or should we not go to war). This model of practical reasoning is used as underpinning method to a deliberation dialogue in more recent research

(Black and Atkinson 2009) to decide on a medical treatment for a patient where a number of options are presented and discussed.

There is a distinction between these two examples that corresponds to a distinction between two types of deliberation: the kind of deliberation called a *dilemma*, where there is a choice between two opposed options and the more flexible problem-solving type which concerns how to solve a problem. In Philosophy, the dilemma type of deliberation seemed to be of a kind that is more often used, where participants are confronted with a governing question such as whether we should do something or not, and then the parties take turns supporting or defeating positions on whether this is feasible, convenient and so on. This may be because of the studies in persuasion, where a similar procedure is instantiated. Interestingly, we observe that this is similar to the influence that computational models of persuasion dialogue have had in deliberative dialogue. The studies in persuasion models, such as in Prakken (2005), have been used to propose dialogue protocols that could fit deliberation types, for example Kok et al. (2011). Initially, the type of examples used were yes-no questions in the form of a dilemma, such as “*Should we invade Iraq? Should we go for pizza?*”. However, later examples have moved to a more problem-solving type of question, such as “*Where should we go for dinner? How do we stop the Iraqi’s war?*” This shift in type of example, however, did not correspond to a shift in the type of deliberation protocols used. The main shift noticed in the literature was that from persuasion protocols being adapted to include moves related to actions or options.

There is a question then raised here as to whether this model, which very well represents the dilemma type of deliberation, is flexible enough to model the latter type of problems when we consider other alternatives that may come to play during the dialogue. We have already shown that the practical reasoning argumentation scheme that underpins dialogue in Black and Atkinson (2009) for example is adequate to pose a problem in the problem-solving deliberation. The examples that we presented in this paper, however, suggest that there are other characteristics that have not previously been investigated. Better understanding of these differences is particularly important for computational models of deliberation that are typically derived from the deliberation of the *dilemma* kind and then directly applied to the problem-solving type of deliberation. This paper presents a more general account of the reasons for which some of those characteristics are yet to be included in existing computational deliberation systems to date, as we previously discussed in Walton et al. (2014). In particular, we suggest that the problem-solving type of deliberation is characterised by the revision of the issue made necessary by the arising of new circumstances. Since our examples show that this revision is a key difference we now present the characteristics of such revision and how may we proceed to formulate a more complete framework for deliberation.

4.1. When does the revision occur?

As we have seen in our examples, the introduction of new information during the dialogue often causes a revision of the issue. This is because that new information highlights alternatives that were not possible before. New information may come from different sources. In the printer example, the observation of consequences of execution of actions may lead to the need for new alternatives. In the gelato example, new information is due to sensing the environment and hence changing the circumstances. We may have an information-seeking process or in the disaster example, new circumstances are discovered through new information shared during dialogue. Similarly, in the car example, new options are identified through values shared during dialogue.

Although representing these different types of new information may require different models in artificial deliberation, these all result in a fundamental difference between problem-solving and other kinds of deliberation.

In Walton et al. (2014), we discussed the possibility of introducing a new speech act, *disclose(Arg)*, to allow for agents to volunteer new information into the dialogue. The MHP model allows for a *revise* phase in which agents may propose changes to the issue as well as to existing facts. This is only permitted through a *propose* speech act with no changes in the commitment store. However, a change of circumstances often requires new information to be asserted, rather than proposed. Our extended model aimed at permitting agents to assert information about new circumstances during the dialogue. We showed for example that the new speech act permits agents to more effectively discuss and resolve conflicts between interdependent plans in scenarios similar to those of the disaster response. While this is a change at the protocol level of dialogue, it must be underpinned by a method to revise the set of alternatives in relation to new information.

There is also the problem of how to revise the knowledge-base but in this paper we focus on the effects on the dialogue. In existing argumentation systems for multiagent dialogue, all the alternatives are constructed at the beginning of the dialogue. When participants have different expertise, such as in Black and Atkinson (2009), alternatives may not be known by all the agents at the outset, however, the problem remains since no change is permitted in the set of options available to agents for discussion.

An open question is: when is the right time to consider a new option and revise the issue? In the disaster response model, we assumed that the new alternative is formed when there is no agreement on the option under discussion. We may be instead in a position of having no further choices as in the case of the bin example. Both of those are extreme cases are ones in which an alternative is needed. This is also the approach taken in Kok et al. (2011). However, there could be open alternatives coexisting such as in the car example or in the gelato example. In these cases a participant in the dialogue feels that there is a new alternative to be proposed when new circumstances highlight different evidence. The other extreme case is that we may construct all the alternatives possible, which leads to an explosion of available options, especially if the decision is not simply on one action but on a sequence of actions to achieve an objective. In this case, a number of criteria would be necessary for the agents to use the existing information in the dialogue and find an alternative that is suitable and relevant. When the alternatives are identified, an individual deliberation may focus on what needs to be changed in the current options in order for an acceptable alternative to be proposed in the discussion. In Black and Atkinson (2009), an example of individual criteria is given in which individual agents decide on the option to be put forward by looking at individual values and the alternatives that are currently available from the shared analysis.

4.2. Dealing with the revision of an issue

The introduction of a new alternative changes the status of deliberation and this must be represented in a system that models deliberative dialogue. In order to do so, the system must allow for a revision of the knowledge of the agents, in particular of those who did not suggest the alternative. In light of our examples, we argue here that in the dialogue, during the revision of the issue phase, referred to as *revision* in the MHP model, the revision of the issue itself should be made more explicit, so that we may track the different sets of options for which agents would

need to make a decision upon. While in the deliberation system of Kok et al. (2011) the tracking of the options available is done via maintaining the options at the root of different dialectical trees, the alternatives that an agent may propose during dialogue are set at the initial stage and the choice is made observing preferences among roots that are *in* according to the arguments exchanged. As previously introduced, in the latest version of the Carneades Argumentation System, not only is it possible to track different issues during the dialogue, but the system is now able to revise the issue as the dialogue proceeds. The Zeno argumentation framework (Gordon and Karacapilidis 1997), the basis of this system, is especially useful for making decisions by evaluating pros and cons and different preferences for different options. This system is designed for supporting human decision-making by modelling reasoning through arguments for and against a decision in a way that differs from the large research effort on decision-making in computer and social sciences but that is closer to human understanding. Such a system may then provide useful insights on how to deal with the revision of an issue in agent deliberation.

The revision of the issue itself may be subject of deliberation, for example, we may ask whether it is worth considering an alternative, or whether there is the need to reduce the number of alternatives. The option tracking will allow for agents to be able to shift the dialogue to a meta-level phase of deliberation about issue revision. In this phase, agents may also decide whether the dialogue is terminated or should terminate. In the computational models of argumentation-based deliberation previously discussed, a new alternative is proposed via a speech act *propose(action)*. However, a new speech act that specifically indicates the revision of the issue introducing or removing a new alternative may be more helpful to represent the transition. This is especially important in the analysis of a deliberative dialogue. In Walton et al. (2014), for example, a number of criteria are expressed for evaluating whether at the closure stage of deliberation the dialogue was successful. One of those criteria states that the success of a dialogue depends on the accuracy and completeness of the information regarding the circumstances of the case. The introduction of a new *revise* speech act would explicitly link a new proposal to the introduction of new information, and may permit us to draw better conclusions on the quality of the proposal and the deliberation.

More generally, with the use of a new speech act we may be able to draw conclusions on whether it was reasonable to revise the issue, whether the new proposal is based on evidence and is relevant within the current deliberation. The notion of relevance also needs some reconfiguration. There needs to be a notion of relevance of the alternatives proposed according to what an agent thinks it is possible to achieve based on the information available. We must also consider the relevance of the moves in the dialogue. Within existing frameworks, the latter is formally approached by Kok et al. (2011) with a notion of relevance of an attacking move defined as one that changes the acceptability of the proposal. However, as we have shown through our examples, when new information is exchanged, for example via a disclose speech act, the acceptability of the existing proposals may not necessarily change but rather new information initiates a phase of revision of the issue. The move of a *revise* speech act in turn may not always lead to a change on the acceptability of the existing proposals, hence a more flexible notion of relevance should be considered within a framework that allows for supporting arguments or explanations to be introduced during the dialogue.

5. Conclusions

The examples studied in this paper show that there is the need to recognize a fundamental distinction between two types of deliberation: the kind of deliberation with fixed multiple choices often associated with the *dilemma*, where there is a fixed choice between mutually exclusive options and a more flexible problem-solving type of deliberation concerning the evolution of changing means of solving a problem as new information comes in. The practical reasoning argumentation scheme is especially important in the problem-solving type of deliberation both for posing a problem and for solving it by group deliberation. The examples that we presented in this paper suggested other characteristics as well that have not previously been investigated. In particular, we proposed that the problem-solving type of deliberation is characterised by the revision of the issue made necessary by the agents' increased knowledge of new circumstances. Existing deliberation frameworks, often developed to represent the dilemma type of deliberation, need to be extended to allow agents to formulate new alternatives as the dialogue proceeds on the basis of the information received. The revision of the issue leads to further considerations on closing criteria and relevance of dialogue moves, hence it should be made more explicit via a new speech act, for example, in order to better analyse the outcome of deliberation. In conclusion, we showed that a more complete framework for deliberation is required to accommodate the features of realistic deliberation revealed by our examples.

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