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A Network of Argumentation Schemes and Critical Questions
Un réseau de schémas d'argumentation et de questions critiques

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Article abstract

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A Network of Argumentation Schemes and Critical Questions

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Abstract: In this paper, we devise a network that consists of argumentation schemes and critical questions that participants in debates can use to easily construct arguments that attack or support former arguments. As a prototype, we build a potential network of argumentation schemes and critical questions with a practical reasoning scheme at its center. The usefulness of a NASCQ in constructing and reconstructing complex arguments and in formal argumentation is also explored along with argumentation more broadly.

Résumé: Dans cet article, nous concevons un réseau composé de schémas d'argumentation et de questions critiques que les participants aux débats peuvent utiliser pour construire facilement des arguments qui attaquent ou soutiennent d'anciens arguments. En tant que prototype, nous construisons un réseau potentiel de schémas d'argumentation et de questions critiques avec un schéma de raisonnement pratique en son centre. Nous explorons l'utilité d'un NASCQ dans la construction et la reconstruction d'arguments complexes, dans l'argumentation formelle et également dans l'argumentation en général.

Keywords: argumentation scheme, critical question, complex argument, formal argumentation

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1. Introduction

Most argumentation begins with an argument being put forward that defends the standpoint adopted by the proponent. Then, the other participant(s) concerns will be most likely twofold: to find any weaknesses in the former argument and to construct a subsequent argument that attacks or supports the former. Essentially, "what is a weakness of this argument?" and "how can I construct an argument that attacks or supports the former?" are two key questions asked by the proponent and the respondent. The proponent tries to find answers to these questions for the sake of bolstering their former argument and in turn defending their standpoint, while the respondent does so in order to cast doubt on the proponent's standpoint and encourage them to reject it. In order to find adequate answers to these questions, both the proponent and respondent can use argumentation schemes and their attendant critical questions.

Argumentation schemes are *molds* for arguments that can be used to construct real arguments. More precisely, argumentation schemes are forms of argument (structures of inference) that represent structures of common types of arguments used in everyday language discourse, as well as in special contexts like those of legal argumentation and scientific argumentation (Walton et al. 2008, p. 1). Most argumentation schemes are accompanied by a list of so-called critical questions which users of the scheme can draw upon to anticipate the kind of objections that may be raised against such an argument. Argumentation schemes and their attendant critical questions play such an important role in identifying, analyzing, evaluating, and constructing arguments in natural language discourse that they have been widely studied in informal logic, rhetoric, and argumentation theory (Hastings 1963; Perelman and Olbrechts-Tyteca 1969; Kienpointner 1992; Walton 1996; Grennan 1997; van Eemeren and Grootendorst 2004; Godden and Walton 2007; Walton et al. 2008; Walton 2008a; Orsinger 2011; Walton 2013a; Macagno 2015; Walton and Macagno 2015; etc.). Although this approach has also been criticized several times (for example, Pinto 2003; Lumer 2016; etc.), argumentation schemes have been employed in a wide range of domains and for many applications including legal reasoning (Walton 2005; Atkin-

son and Bench-Capon 2021), decision support systems (van der Weide et al. 2006; Atkinson et al. 2008), ethical reasoning (Atkinson and Bench-Capon 2008a), argumentation framework (Atkinson and Bench-Capon 2008b; Gordon et al. 2007), argument interchange format (Rahwan et al. 2011), AI education (Green 2017), and even medical reasoning (Qassas et al. 2015).

The list of critical questions accompanying an argumentation scheme helps the participants to easily answer the question, "what are the weaknesses of this argument?" One of the features of argumentation schemes that is key to evaluating whether an argument fitting a scheme should be judged as strong or weak is the list of associated critical questions—questions that can be asked (or assumptions that are held) by which a non-deductive argument based on a scheme might be judged to be (or presented as being) good or fallacious (Walton et al. 2008, pp.15-16). In fact, the set of critical questions accompanying a scheme allows for the vulnerabilities of an argument fitting the scheme to be identified. Thus, if a respondent identifies the argumentation scheme that the proponent's argument fits, then they can easily pinpoint its weakness using the list of critical questions attached to the scheme.

After the weaknesses of the initial argument are identified, the second question can be raised: "how can I construct an argument that attacks or supports the former one?" The answer to the first key question may inspire the answer to this one. In other words, the participants can construct arguments that attack or support the former argument simply by backing up an answer to a critical question attached to the scheme that the former argument fits. In fact, an answer to the question and support for it together comprise an argument. The argument consists of an answer to the question as the conclusion and support for the answer as the premises.

Furthermore, we know that argumentation schemes can be a powerful means for constructing arguments. We can easily construct real arguments simply by substituting for the variables of an argumentation scheme. This means that argumentation schemes can be instantiated to construct an argument that backs up answers to a critical question. For example, we can apply the argumentation scheme from position to know to back up an answer to the *trustworthiness* question ("is expert E reliable as a source?") of an

argument from expert opinion as follows: "*source A is in position to know about the expert E's trustworthiness. Source A asserted that E is reliable. Therefore, E is reliable.*"

However, it is not the case that we can apply every argumentation scheme as support for an answer to a critical question since the application of a scheme partly depends on the *semantic* nature of the thesis to be proved. The semantic[1] nature of a thesis is usually related to what kind of content the thesis contains rather than its logical form. While the logical nature of a thesis is related to its logical form, for example, whether the proposition that expresses the thesis is positive or negative, universal or particular, and so on, the semantic nature of a thesis is often related to its content, for example, whether it is about a property of things, a causal relation, an evaluation of something, or the desirability of an action, etc.[2]

Not all of the semantic (material) relations that form the basis of the schemes can support all the possible conclusions or purposes of an argument (Macagno 2015, p. 193). Therefore, we cannot arbitrarily apply argumentation schemes to back up an answer to a critical question. For example, we cannot apply the scheme for practical reasoning or the one for argument from waste to back up an answer to the *interfering factor* question: "are there other causal factors that could interfere with the production of the effect in the given case?" It is clear that these two schemes, if applied, would give irrelevant answers to the question. We can apply the schemes for practical reasoning and argument from waste only to assessing whether a course of action is desirable. Similarly, we can apply the scheme for argument from correlation to cause only to support a causal relation.

In summary, only certain argument schemes can give a relevant answer to a critical question and what schemes are available to back up a particular answer depends on the semantic nature of the question. Furthermore, generally, the kind of answer to a critical

[1] The technical term 'semantic' is frequently used in Macagno (2015) and Macagno and Walton (2015) where they contrast it with the term 'logical' and classify and systemize clusters of argumentation schemes according to the semantic nature of the thesis to be proved.

[2] The classification of theses (theses about a property of things, a causal relation, an evaluation, or a proposal) is taken from Fahnestock and Secor (1982).

question that an arguer tries to back up does not influence their selection of suitable schemes, as will be demonstrated in the next section.

However, while selecting the schemes that are likely to provide relevant answers to a critical question, we could not help but wander about in the conventional scheme repertories. This is because schemes are not grouped according to critical questions. In the conventional scheme repertories, a list of critical questions is attached to each argumentation scheme, which is separate from the others. What is more, the critical questions are not followed by any scheme (see Fig. 2). In a nutshell, a scheme repertory is useful only for helping the participants determine an answer to the first key question, but not for the second key question.

The purpose of this paper is to help users of argumentation schemes and critical questions find answers to both key questions. If we attach schemes to each critical question, critical questions can act as *bridges* between argumentation schemes. As a few critical questions are attached to a given argumentation scheme, so too can a few argumentation schemes be attached to a critical question. While a set of critical questions attached to a scheme helps identify the weakness of an argument fitting the scheme, a set of argumentation schemes attached to a critical question offers reasoning patterns that are suitable for use in justifying an answer to the critical question. Thus, an argumentation scheme can be connected through critical questions to the other schemes.

From this perspective, we define a new notion, which we term "network of argumentation schemes and critical questions" (NASCQ). In a NASCQ, critical questions are grouped according to argumentation schemes and argumentation schemes are grouped according to critical questions. So, it serves to help argumentation participants find answers for both key questions.

The rest of this paper is organized as follows: in section 2, we deeply scrutinize two kinds of possible answers to a critical question. We also investigate whether this dichotomy restricts the selection of schemes appropriate to back up an answer to a critical question. The definition of a NASCQ is given in section 3. In section 4, we distinguish two important kinds of argumentation schemes: thesis-dependent and thesis-independent, which is useful

for developing a NASCQ. Section 5 is dedicated to developing an example of a NASCQ. Its usefulness in constructing and evaluating complex arguments and in formal argumentation is briefly explored in sections 6 and 7.

2. Two kinds of answers to a critical question

A critical question has a number of possible answers, and thus, the kind of answer a participant is attempting to back up with evidence is important. This is because the set of argumentation schemes that can be applied to back up an answer to a critical question may be determined not only by the semantic nature of the question but also by the kind of answer an arguer tries to back up.

Asking a critical question merely casts the argument into doubt and thus does not imply a stance. There may be two kinds of answers to a critical question: positive and negative. In a nutshell, the positive answer to a critical question may be "yes," while the negative may be "no." For example, if the *trustworthiness* question of the scheme for argument from expert opinion—"is the expert reliable as a source?"—has been asked, then the answer "yes, they are reliable" is positive, while "no, they are not reliable" is negative. However, not all of the critical questions take the form of a yes/no question. Furthermore, even questions with the yes/no form do not all play the same role in argumentation. For example, the answer "yes" to the *trustworthiness* question of an argument from expert opinion plays the role of supporting the original argument, while, on the contrary, the same kind of answer to the *other means* question[3] of a practical reasoning argument or the *third factor* question of an argument from correlation to cause play the role of attacking the original argument fitting the scheme. Therefore, we can regard the positive answer as an answer that is favorable to the proponent and the negative answer as an answer that is favorable to the respondent. In other words, the positive answer to a critical question is one that supports an argument fitting the scheme it attaches to, while the negative answer is one that attacks an argu-

[3] The *other means* question of practical reasoning is "[a]re there alternative possible actions to bringing about S_i that could also lead to the goal?" (Walton et al. 2008, p. 96)

ment fitting the scheme. Consequently, the positive answers can be taken as the premises of an argument fitting the scheme and the negative ones can be taken as rebuttals, or as undercutting or undermining the original argument. For another example, if the *expertise* question[4] of an argument from expert opinion that does not take the yes/no form has been asked, then "they are a credible expert" and "they are not a credible expert" are respectively positive and negative answers to the argument.

Given our definition, whether an answer to a critical question is positive or negative may be inconsistent with the sentence form of the answer. For example, a linguistically negative sentence "No, there is not a third factor" should be considered a positive answer to the *third factor* question.

From the definition, backing up a negative answer to a critical question boils down to constructing an argument that attacks the former argument fitting the scheme to which the question is attached, whereas backing up a positive answer to a question boils down to constructing a supporting argument.

In remarkable contrast to the fact that the semantic nature of a critical question significantly restricts our selection of schemes, whether we try to back up a positive or negative answer to a critical question hardly restricts our selection of schemes. It just determines which type of argumentation scheme we should employ. That is, if we use the positive form of an argumentation scheme for backing up a positive answer to a critical question, then, we may have to use the negative form for backing up a negative answer. And, if we use the negative form of a scheme for backing up a positive answer to a critical question, then, we should use the positive form for backing up a negative answer. Moreover, many argumentation schemes, such as the schemes for argument from consequences and argument from values, have positive and negative forms. For example, we can not only establish the desirability of a course of action by instantiating the positive form of the argumentation scheme from consequences (argument from positive consequences) but also its undesirability by instantiating the nega-

[4] The *expertise question* of argument from expert opinion is "[h]ow credible is E as an expert source?" (Walton et al. 2008, p. 310)

tive form (argument from negative consequences). In Walton's original exposition of argumentation schemes, some schemes do not have positive and negative forms; however, it is possible to conceive of two opposite forms for every scheme. For example, in the same way that the existence of a causal relation is drawn from the observation of a positive correlation between two events, the non-existence of a causal relation can be drawn from the claim that a positive correlation has not been observed. Therefore, the scheme from correlation to cause has positive and negative forms.

In more general terms, whether a positive or negative answer follows from a scheme just depends on what we substitute for the variables of the scheme. That is, arguments that back up a negative answer to a question may be easily given by substituting negative (or sometimes positive) terms for the variables of an appropriate scheme. That is why Lumer (2016) criticizes Walton's argumentation scheme approach for adding the variant "false" into many argumentation schemes, such as the scheme from expert opinion. According to him, it is superfluous to express both the positive and negative variants for every proposition in a scheme since a negative variant proposition can easily be created by substituting negative terms for a variable in a positive proposition. For example, the proposition "*e* asserts that proposition *p* is false" is equivalent to "*e* asserts that proposition non-*p* is true" in the scheme from expert opinion (Lumer 2016, p. 5).

Notably, some schemes have critical questions about the existence of certain types of things, such as the *other goals*[5] or *other means* question of the practical reasoning scheme or the *third factor* question of the scheme for argument from correlation to cause. For such questions, we can prove the existence of these things simply by providing an example; however, non-existence in an example doesn't prove that things of that sort do not exist. For instance, suppose that the other goals question has been asked. The respondent can easily construct an argument that backs up the negative answer, "yes, there is one other goal G," by instantiating a scheme, such as that for argument from values (see Fig. 4).

[5] The *other goals* question for the practical reasoning scheme is "do I have goals other than S_i whose achievement is preferable and that should have priority?" (Walton et al. 2008, p. 96)

However, for the proponent, it is much more challenging to prove the positive answer, because denying the existence of the example goal G is insufficient to deny the existence of all possible goals. Therefore, for critical questions about the existence of something, it seems to us that different kinds of answers to a critical question cannot be dealt with simply by appealing to different forms (positive or negative) of a scheme or substituting different (positive or negative) terms for the variables of the scheme.

Given this, our justification is twofold. First, we insist that the critical question about the existence of something should be more specific than the present one. In other words, such questions should have the form "is a particular thing…?" rather than "are there…?" For example, a more specific form of the other goals critical question may be "is the achievement of the goal G preferable to S_i?" For this question, arguers can easily support its positive and negative answers by appealing to the positive or negative form of a scheme (argument from values in Fig. 4), respectively.

Second, even in such cases, it is possible to back up the answer by applying the opposite form of a suitable argumentation scheme. In everyday argumentation, one of proponents' usual tactics for dealing with critical questions about existence is to enumerate possible choices and then prove that all those choices are unavailable. In our example, the proponent can prove the non-existence of *other goals* by proving an argument "*The possible goals other than my goal may be* G_1, G_2, *..., but none of them should be pursued. Thus, there aren't any other goals.*" This can, in turn, be, supported by employing the negative form of the scheme from values (argument from negative values) several times. How many times we apply the scheme depends on the number of other possible goals. Dealing with critical questions about existence in such a way is a kind of argument from ignorance in everyday argumentation (Walton 1996; Walton et al. 2008) or negation as failure type reasoning, which is adopted for modeling the "*closed world assumption*" in AI.

As a result, we can say that the set of argumentation schemes that can be applied to back up answers to a critical question is determined only by the question, not by the kind of answer that needs to be backed up. This allows us to attach a set of schemes to

a critical question no matter what kind of answer needs to be proven. Consequently, this allows us to define the concept of a NASCQ as we do in the next section.

3. Definition of NASCQ

A NASCQ is a constellation of schemes connected through critical questions. Different argumentation schemes and critical questions are interwoven together to form a NASCQ. It is a directed network that includes two kinds of nodes and two kinds of directed edges. The two kinds of nodes are the argumentation scheme node (AS-node) and the critical question node (CQ-node). The two kinds of directed edges are the *ask edge* which goes from a CQ-node to an AS-node and the *backup edge* which goes from an AS-node to a CQ-node. There can be no edge that goes from an AS-node to another AS-node. There can be no edge that goes from a CQ-node to another CQ-node, either. In a NASCQ, one AS-node is connected to the other AS-nodes only through CQ-nodes. The figure below depicts a NASCQ that includes five schemes and eight critical questions. Rectangles represent schemes and rounded rectangles represent critical questions. In addition, dashed lines represent *ask edge*s, while solid lines represent *backup edge*s. As you can see, three critical questions (CQ-2, CQ-3, CQ-5) are connected to the argumentation scheme (Sch-1) through *ask edge*s to point out the vulnerabilities of an argument fitting the scheme. The critical question (CQ-4) is connected to two schemes (Sch-1, Sch-3) through *backup edge*s, which means that these schemes can be used to construct arguments that back up an answer to the question.

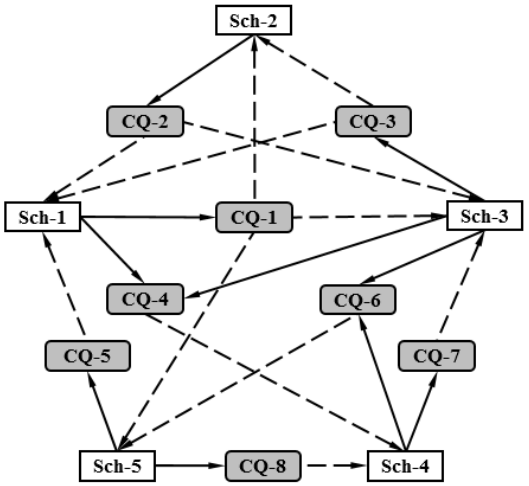

Fig. 1 A NASCQ

A scheme repertory has two kinds of nodes, but only one kind of edge that goes from a CQ-node to an AS-node, and for this reason, it remains just a simple collection of isolated argumentation schemes. That is, in a scheme repertory, argumentation schemes are not connected with each other in any manner. The following figure depicts an example of scheme repertory that corresponds to the NASCQ depicted in Fig. 1.

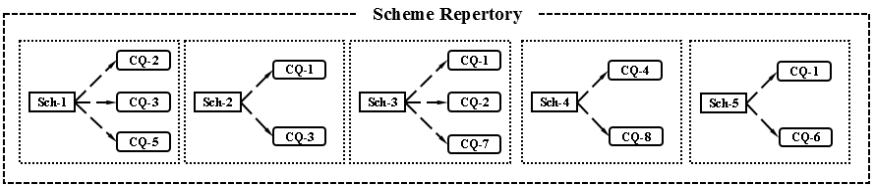

Fig. 2 An argumentation scheme repertory

Unlike scheme repertories, in a NASCQ, argumentation schemes are connected with each other through the "bridges" of critical questions. A critical question, which is connected with a scheme through an *ask edge*, represents the vulnerabilities of an argument fitting the scheme and can in turn be used to evaluate the argument. And a scheme, which is connected with a critical question through a *backup edge*, can be used to construct arguments that back up an answer to the question. Therefore, a NASCQ helps

argumentation participants find answers to the questions "what are the weaknesses of this argument?" and "how can I construct an argument that attacks or supports the former?" after an argumentation scheme that the former argument fits has been identified.

It is also possible to imagine a NASCQ that involves only one kind of node and one kind of edge. In this kind of NASCQ, the nodes represent argumentation schemes and the edges stand for critical questions. Thus, every node is labeled with the name of a scheme, while every edge is labeled with the name of a critical question, as in Fig. 3 below.

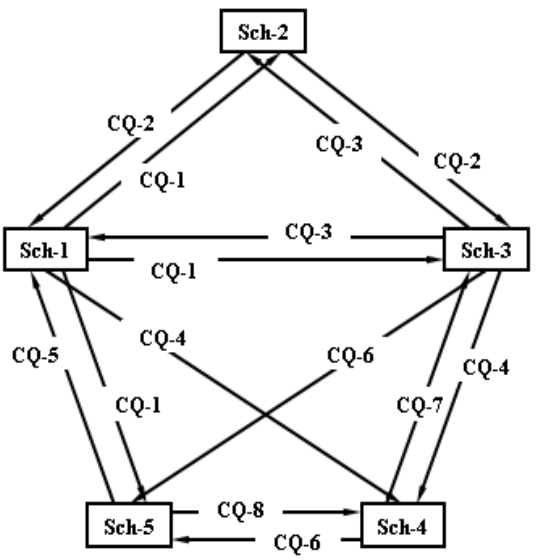

Fig. 3 A NASCQ with AS-nodes and CQ-edges

The critical questions are represented by edges in Fig. 3, which may produce the misunderstanding that a critical question is given just as an answer justified only by means of a scheme. In real argumentation, participants often provide different answers to the same critical question and justify their answers by means of diverse schemes. This is why it is better for critical questions to be represented by nodes than by edges in a NASCQ.

In order to build a real NASCQ, it is essential to determine how we can specify the schemes that can be applied to support an

answer to a critical question in a substantial way. In the next section, a small part of the solution to this issue is addressed.

4. Thesis-dependent and thesis-independent argumentation schemes

As mentioned in the first section, proponents and respondents cannot arbitrarily apply argumentation schemes to support an answer to a critical question because choosing schemes usually depends upon the semantic nature of the thesis to be proved. But can we apply an argumentation scheme to support arbitrary critical questions? We found that, for some argumentation schemes, the answer is "yes." but for the others, the answer is "no." Some argumentation schemes can be applied to every critical question while the other schemes can be applied only to particular critical questions.

In argumentation practice, the arguer's choice of schemes depends on the semantic nature of the thesis. For example, if a thesis is about the desirability of a course of action, we can apply the schemes for practical reasoning and those for argument from waste, consequences, established rules, need for help, danger appeal, distress, and threat. In contrast, for the same thesis, we cannot apply the schemes for argument from sign, abductive argument, argument from cause to effect, and argument from correlation to cause because their conclusions are irrelevant to the desirability of a course of action. So, we call such schemes *thesis-dependent*.

However, most of the source-based argumentation schemes and the scheme for argument from analogy can be applied to any thesis, irrespective of their semantic nature. So, we call these *thesis-independent* schemes.

A source-based scheme proves a thesis based on two factors: the presence of an agent that is in a position to know something related to the thesis, and the fact that the source has committed to the thesis. In most cases, there is no constraint on the kinds of theses to which a source is allowed to commit; a source can commit to any theses. For example, an expert can give advice about what choice should be made or can present their opinion on what statement should be believed. For this reason, most source-based

argumentation schemes can be applied to any kind of thesis. Note that there are some source-based argumentation schemes that we cannot include under the heading of thesis-independent schemes, such as the one for argument from witness testimony. Indeed, a witness—a person who has experienced an event such as a crime or an accident—is only allowed to state that something is true or false but is not allowed to assess the desirability of a course of action in a court. We classify the scheme for argument from analogy as *thesis-independent* also because there is no constraint on the semantic nature of conclusions that can be drawn from comparison between similar cases. Arguers can establish not only the desirability of a course of action but also the acceptability of a judgment based on an argument from analogy.[6]

How can we decide whether an argumentation scheme is thesis-dependent or thesis-independent? Unlike traditional logical inference patterns like modus ponens or syllogisms, which are highly abstract, contemporary argumentation schemes are based on their own semantic relations as well as logical relations. Argument from cause to effect, for example, is not only based on defeasible modus ponens, but also on a semantic causal relation between two events (Macagno 2015; Macagno and Walton 2015). An argumentation scheme may either be relevant to any kind of thesis or be relevant to only a certain kind of thesis according to the semantic relation it is based on. This requires us to thoroughly investigate the conclusions that can be drawn from the application of a scheme in order to determine whether it is thesis-dependent or thesis-independent. Argument from position to know, for another example, can draw any kind of conclusion. There may be a person who is in a position to know what to believe, what causes what, what to do, what is good or bad, right or wrong, and any other kind of claim. The semantic relation between a source's commitment to a proposition and the acceptability of the proposition is relevant to any kind of thesis. However, argument from sign, which is based on the se-

[6] There have been many debates over the formulation of the scheme for argument from analogy. However, we say that, regardless its formulation, the analogical argumentation scheme is thesis-independent unless we set any constraint on possible conclusions that can be drawn from that kind of argument, as in the practical variant of the scheme.

mantic relation between a sign and an event, can only draw conclusions about the property of something or the occurrence of something, but it cannot draw any conclusions about whether a particular action is desirable (see Fig. 4). The semantic relation between a sign and an event is completely irrelevant to establishing the desirability of bringing about a particular action.

Schemes are basically classified as thesis-dependent or thesis-independent according to the form of their conclusions. If any claim can be reduced to the form of the conclusion of a scheme, then it is thesis-independent otherwise the scheme is thesis-dependent. We can easily see that no claim can be reduced to the form of the conclusion of the scheme from cause to effect ("therefore, in this case, B will occur"), the scheme from correlation to cause ("therefore, A causes B"), the practical reasoning scheme ("therefore, I ought (practically speaking) to carry out this action A"), the scheme from values ("V is a reason for retaining (retracting) commitment to goal G"), or the scheme from classification ("A has property G."). By substituting the variables of the conclusions, we cannot get any kind of claims other than claims about the occurrence of something, a causal relation, the desirability of bringing about an action, the desirability of pursuing a goal, or the property of something, respectively (Walton et al. 2008). That is why those schemes are categorized as thesis-dependent. But it is self-evident that any claim can be reduced to the form of the conclusion of the schemes from analogy, expert opinion, position to know ("therefore, A is true."), and thus, the schemes are categorized as thesis-independent. However, this rule of thumb for categorization may not hold for some schemes, such as those of argument from sign or argument from witness testimony. Although, it seems like any kind of conclusion can be reduced to the form of the conclusions of argument from sign or witness testimony ("B is true in this situation," "A may be plausibly taken to be true"), upon deeper inspection, as argued above, only certain kinds of conclusions can be drawn by applying those schemes (Walton et al. 2008). Therefore, to determine thesis-dependence or thesis-independence, it is more accurate to carefully consider the conclusions that can be drawn by applying a scheme.

Since most of the source-based argumentation schemes and the scheme for argument from analogy are thesis-independent, arguers can apply them to support answers to any critical questions. Thesis-dependent schemes, on the other hand, can be applied to support answers to just a few critical questions. For example, argument from waste and argument from consequence can support an answer to the other means question of the scheme for practical reasoning. But they cannot provide a relevant answer to the possibility question or the side effect question for the same scheme. We do not mean that a thesis-dependent scheme can be applied to support an answer to only one critical question. If a scheme is thesis-dependent, there exists at least one critical question, and any answers that are appropriate to answer it cannot be supported by employing the scheme. For example, argument from cause to effect is thesis-dependent, and it cannot be used to support an answer to any critical questions other than the possibility question and the side effect question in Fig. 4.

So then, what schemes can be applied to support the answers to each critical question? In order to answer this question, we need to focus on the conclusion of every scheme. If the conclusion of a scheme can become an appropriate answer to a critical question, the scheme can be applied to support the answers to the question.

Our careful scrutiny of the conclusions of Walton's argumentation schemes (Walton et al. 2008) resulted in the following NASCQ.

5. A potential NASCQ

To begin with, we'd like to mention that this network is potential and incomplete. It is potential because all of its edges indicate possible relations between argumentation schemes and critical questions. In other words, it is not a model of a real or finished argumentation. It is also incomplete because it does not involve all of the recognized argumentation schemes and critical questions. A journal article is too limited in size to discuss all relations between them. So, we restrict the network to some of the relations with practical reasoning at the center.

In this paper, we present a prototype of a NASCQ that was developed based on Walton et al.'s comprehensive work (2008).

Building a full and complete NASCQ is not the aim of this paper. A larger NASCQ that involves other scholars' schemes will be undertaken in the future.

In this section, we stake the practical reasoning scheme as our starting point to build a network. A starting point is always required to create a network. We adopt the practical reasoning scheme as our starting point because it is very common and important in human reasoning.[7] Therefore, the application of a NASCQ is not restricted to practical argumentation. Rather, a NASCQ can be applied to a wide range of reasoning and argumentation, including those about properties of things, causal relations, evaluations, or proposals. For example, the NASCQ can be used in causal argumentation since it includes causal argumentation schemes, such as argument from cause to effect, argument from sign, and argument from correlation to cause.

In the figure below, solid arrows represent *backup edge*s, while dashed arrows represent *ask edge*s. A simple rectangle with a label inside it represents a thesis-dependent argumentation scheme and a snip diagonal corner rectangle with the label inside it represents a thesis-independent argumentation scheme. Finally, rounded grey rectangles with labels represent critical questions. In fact, snip diagonal corner rectangles should be connected with all the rounded rectangles since thesis-independent schemes can be used to construct arguments that back up any critical question. However, connecting every thesis-independent scheme with all critical questions makes the NASCQ very intricate and hard to understand. Therefore, in this NASCQ, we distinguish thesis-independent schemes from thesis-dependent schemes by using different rectangle types.

[7] This does not mean that a NASCQ centered around the practical reasoning scheme should be different from one centered on another scheme. NASCQs may vary in their incomplete forms just because the schemes and question they involve may be different. However, regardless of which scheme we start from to build a NASCQ, the full and complete versions should mostly be the same, as long as they involve the same schemes and question. Furthermore, the complex relationship between argumentation schemes and critical questions is based on human real argumentation and is thus objective.

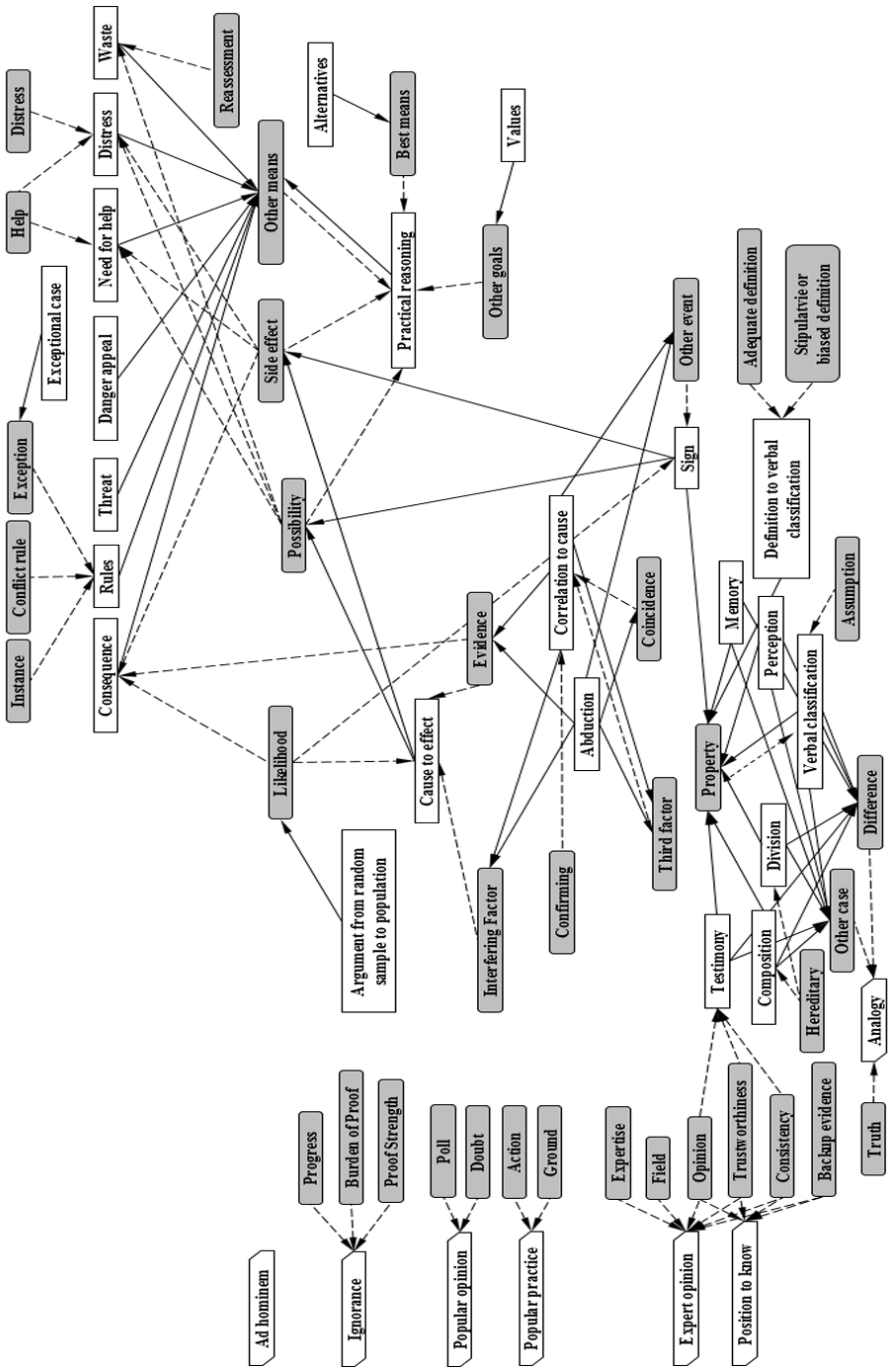

Fig. 4 A potential NASCQ

It is redundant to present the full details of every argumentation scheme because it can be found in the compendium of schemes in Walton et al. (2008, pp. 308-346).

What is important about the NASCQ is that we gave every critical question a name like we did in the earlier version of the scheme for practical reasoning (Walton et al. 2008, p. 96). Some critical questions attached to different schemes share the same name since they can be identified with each other with respect to their semantic nature. For example, CQ_5 for practical reasoning, CQ_3 for argument from need for help, CQ_4 for argument from distress, and CQ_3 for argument from consequences are very similar in the sense that they all inquire about the existence of a bad or undesirable consequence of bringing about a course of action. Therefore, they are given the same name, "*side effect question,*" in this paper.

In addition, in Fig. 4, there are such critical questions as the *instance* question or the *conflict rule* question that are not connected to any thesis-dependent argumentation schemes by a *backup* edge. The reasons for this are twofold. One is that an answer to such a critical question may be a factual claim whose truth should be assured by our sensory organs rather than by arguments. The other is that we failed to find any thesis-dependent argumentation schemes suitable for backing up the questions in the compendium of schemes of Walton et al. (2008). However, the questions can be backed up by any thesis-independent schemes.

Below, we try to provide the details of Fig. 4, question by question so that the readers can easily understand and utilize the NASCQ. We focus on which argumentation schemes can be applied to support the answers to a critical question. Herein lies the core of our paper.

In what follows, to illustrate our approach, we adopt an imaginary example of an instance of argumentation that concerns a larynx cancer case where several medical experts deliberate about the best treatment for a patient with early-stage superficial unilateral larynx cancer, inspired by Qassas et al. (2015). Suppose that the argumentation starts from an argument fitting the practical reasoning scheme put forward by a surgeon: "*Our goal is to pro-*

vide the best cure rate. Hemi-laryngectomy is a means to achieve the goal. Therefore, we should perform a hemi-laryngecomy." (**A_1**) This will be used as a running example throughout this section.

The other goals question is about the existence of a goal other than the one being considered. It is CQ_1 for practical reasoning and an answer to it can be supported by applying the scheme for argument from values. This is because an argument from values takes a value judgment as a reason for retaining or retracting commitment to a goal. The question, "are there any other goals other than the best cure rate for larynx cancer?" is an example of an other goals question and a negative answer to it could be, "yes, there are; another goal could be to avoid any treatment risk." Then, this kind of answer can be supported by instantiating the argumentation scheme from values: "*Avoiding any treatment risk will promote the value 'life,' so we should pursue the goal (thus, we should not perform the operation).*"[8] (**A_2**)

The other means question is CQ_2 for practical reasoning. It asks whether there is another action that should be considered. We can support an answer to it by applying several argumentation schemes. Specifically, the schemes that establish whether a course of action is desirable by appealing to various factors, such as consequences, threat, rules, danger, need for help, distress, and waste. The other means question can even take the practical reasoning scheme as a means to back up its answers. In fact, the respondent may back up the other means question by making an appeal to another goal an agent should also pursue. In our exam-

[8] The expression of this argument from values does not seem to accord with the standard form of the corresponding scheme in Walton et al.'s compendium (2008, p. 321), but we are sure that it follows the general pattern of an argument from values. Such an expression of an argument from values is inspired by the extended version of Atkinson and Bench-Capon's practical reasoning scheme (2007, 2008). According to Atkinson and Bench-Capon, values denote some actual descriptive social attitude/interest that the proponent of an action may or may not wish to uphold or subscribe to. Those descriptions may be '*life,*' '*liberty,*' '*happiness,*' or others and not numeric quantities (2008, p. 138). The difference between the notions of value and goal can also be found in Atkinson and Bench-Capon (2008).

ple, one of the other means questions may be "are there any alternative treatments that could be used instead of taking out the patient's larynx?" And "no, there aren't any possible alternatives" is the positive answer to it. We can support the positive answer to this typical question about existence as follows: "*It may be possible to use radiotherapy or take out the patient's larynx, but we cannot choose either since radiotherapy will lead to low voice quality and taking out the larynx will lead to voice loss. Therefore, there aren't any alternative treatments*" (**A$_3$**). As can be seen, to support the answer to the question about existence, we adopt the argument type from ignorance or negation as failure type reasoning and employ the scheme for argument from consequences twice.

The best means question is CQ$_3$ for practical reasoning. It asks which is the most efficient among possible means; for example, "is hemi-laryngectomy the best among alternatives?" The best means should always be more efficient than any of the alternatives. Since an argument from alternatives recommends one of two candidate means, it is applicable to back up an answer to the best means question. It is also notable that if there are *n* alternatives to a proposed action, an arguer should apply the scheme *n* times. We can support the positive answer to the best means question of our running example by using argument from alternatives as follows: "*The possible alternatives are radiotherapy and taking out the larynx. Thus, either hemi-laryngectomy or radiotherapy can be selected. Radiotherapy is not our choice (because it fails to ensure voice quality). Thus, we should select hemi-laryngectomy. In addition, either hemi-laryngectomy or taking out the larynx can be selected, but we cannot choose to take out the larynx (because it will cause voice loss). Thus, we should, once again, select hemi-laryngectomy. To sum up, hemi-laryngectomy is the best among alternatives.*" (**A$_4$**)

The possibility question is shared by several argumentation schemes including practical reasoning (CQ$_4$), argument from need for help (CQ$_2$), argument from distress (CQ$_3$), and argument from waste (CQ$_1$). This question merely inquires whether a course of

action is possible or not in a given circumstance. For example, we can ask "is it possible to perform the hemi-laryngectomy for the patient?" The arguers can support the possibility of bringing about an action under a given circumstance by applying the schemes for argument from cause to effect and argument from sign. In such a case, the arguers should mention a causal relation or symptomatic relation between a given circumstance and an action as a reason for the possibility. The arguers can argue "If B occurs, then it will become possible to bring about action A. B might occur. Therefore, in this case, it is possible to bring about A" (argument from cause to effect). Or they can argue, "bringing about action A is possible when its sign B is true. B is true in this situation. Therefore, it is possible to bring about A" (argument from sign). If we want to back up the negative answer to the example possibility question, we can construct an argument from cause to effect: "*the patient's old age is a cause that makes the hemi-laryngectomy impossible, and given that the patient is over 75, it is impossible to perform the operation*" (**A_5**).

The side effect question is also connected with several argumentation schemes. The schemes for practical reasoning (CQ_5), argument from need for help (CQ_3), argument from distress (CQ_4), and argument from consequences (CQ_3) share this question. It asks about the existence of a negative consequence of bringing about the action under consideration. "Would hemi-laryngectomy have any known negative consequences that ought to be taken into account?" can be a side effect question. We could not find the phrase "side effect" in the scheme for argument from consequences; however, "other opposite consequence" is used, and we believe they have the same meaning. The arguers can construct arguments that support an answer to this question by means of the schemes for argument from cause to effect and argument from sign. As you can see, the *possibility* question and the *side effect* question can be backed up by applying the same two argumentation schemes. This is because the *side effect* question is essentially about the *possibility* of a negative outcome. We can argue, "*yes, there exists a side effect. That is to say, the patient might suffer from low voice quali-*

ty because hemi-laryngectomy is one of the main causes of lowering voice quality" (**A_6**).

The likelihood question is CQ_1 for argument from consequences, and, simultaneously, CQ_1 for argument from cause to effect and CQ_1 for argument from sign. The point of these three critical questions is to determine the likelihood that one event will (may, must) occur given that the other event has occurred. More precisely, CQ_1 for argument from consequences is about the "likelihood that the cited consequences will (may, must) occur" (Walton et al. 2008, p. 332) given that a course of action was brought about. CQ_1 for argument from cause to effect inquires about the strength of a causal generalization, in essence, the likelihood that the effect will occur given that the cause occurred. In addition, CQ_1 of argument from sign is about "the strength of the correlation of the sign with the event signified" (Walton et al. 2008, p. 329)—that is, it is about the likelihood that an event occurred given that its sign is true. We unify these three questions under the heading of "*likelihood question*." Here, terms such as "likelihood" or "strength" have probabilistic meaning,[9] and thus an answer to the question should have the form "x%." This means that no thesis-dependent scheme can be applied to construct an argument that backs up the question except for the scheme for argument from random sample to population. In our running example, we have constructed an argument from cause to effect **(A_6)** to support the existence of the side effect of hemi-laryngectomy. Now suppose that a likelihood question has been asked: "How strong is the causal generalization between hemi-laryngectomy and low voice quality?" We can respond, "*according to a comprehensive study of a number of larynx cancer patients who have had a hemi-laryngectomy, only approximately 3% of them suffer from low voice quality. Therefore, the likelihood is 3%—very, very low*" (**A_7**).

[9] From a mathematical standpoint, the term "possibility" also has a probabilistic meaning. However, the possibility question has the form of "is it possible?" not "what is the possibility?" and thus we cannot apply the scheme for argument from random sample to population. Instead, we can apply the schemes for argument from cause to effect and argument from sign.

The evidence question is shared by two important schemes: argument from cause to effect (CQ_2) and argument from consequences (CQ_2). We identify these two questions because both of them are about the existence of evidence that warrants the relation between a cause and an effect (argument from cause to effect) and an antecedent and a consequence (argument from consequences). The arguers can appeal to correlation or abduction to back up such a question. Some of the most important evidence one can have to argue for the existence of a causal relationship between two events is a correlation between them (Walton et al. 2008, p. 173). Furthermore, the explanation of an abductive argument is, in most cases, a causal generalization, and that is why it can be said that "it might be better to express it (argument from effect to cause) explicitly as a species of abductive argument" (Walton et al. 2008, p. 171). This means that the existence of a correlation between two events or the hypothesis that one causes another can be taken as evidence that supports a causal relation between them. In our example, we have tried to prove the impossibility of performing a hemi-laryngectomy by appealing to the causal relation between the patient's age and treatment risk (A_5). Thus, the evidence question asks "is there enough evidence to warrant the causal relation between the patient's age and treatment risk?" We can then construct an abductive argument as follows: "*patient A (who also suffers from larynx cancer but is different from the patient under discussion) is very young and has undergone the hemi-laryngectomy. The operation was successful and there was no risk for patient A. However, patient B (who suffers from larynx cancer and is also different from the former two patients) has also had the hemi-laryngectomy, but he was very old, 75. There was a risk for patient B. The best explanation for these facts is that old age is a cause of treatment risk*" (**A_8**).

The interfering factor question is CQ_3 for argument from cause to effect. The existence of an interfering factor means there is another causal relation between that factor and the absence of the effect cited in the original argument. Therefore, backing up an interfering factor question can be distilled to supporting another causal relation. This suggests that we can apply the schemes for

argument from correlation to cause and abductive argument to back up that question. For example, in order to argue for the existence of an interfering factor B that blocks the occurrence of A, we should support a causal relation between B and not-A; thus, we can construct arguments like "a positive correlation between B and not-A is observed; therefore, there exists a causal relation between B and not-A, and B is an interfering factor" or "the causal relation between B and not-A explains the collected data well; therefore, there exists a causal relation between B and not-A, and B is an interfering factor." In the case of our running example, a respondent may ask about the existence of an interfering factor in the causal relation between old age and treatment risk **(A_8)**. In this case, the patient's good health can be such an interfering factor, the existence of which can be supported by means of an argument from correlation to cause: "*there is a positive correlation between old but healthy larynx cancer patients and not having treatment risk; therefore, the patient's good health is an interfering factor*" (**A_9**).

The instance, conflict rule, and exception questions are the critical questions (CQ_1, CQ_2, and CQ_3) for the scheme for argument from rules (Walton et al. 2008, p. 343). It is self-evident that we can support an answer to the exception question by applying the scheme for argument for exceptional case (Walton et al. 2008, p.344).

The help question, which inquires whether the proposed action really helps someone else, is shared by the scheme for argument from need for help (CQ_1) and argument from distress (CQ_2).

The distress question is CQ_1 for the scheme for argument from distress and inquires whether someone is really in distress.

The reassessment question is CQ_2 for the scheme for argument from waste.

The confirming question is the first in the list of critical questions for the scheme for argument from correlation to cause (CQ_1). This

question requires the arguer to confirm the real existence of two events.

The third factor question is an important part of the scheme for argument from correlation to cause (CQ_1). Since a third factor is one that causes both correlated things, providing support for an answer to the third factor question once again boils down to providing support for two other causal relations. For instance, suppose there exists a correlation between A and B, and the existence of a third factor C is revealed. Then, we need to support the causal relations between C and A and between C and B. Therefore, we can use the schemes for argument from correlation to cause and abductive argument to provide support for the answer to that question: "A positive correlation between C and A is observed, therefore C causes A. A positive correlation between C and B is observed, therefore C causes B. Eventually, C constitutes a third factor between A and B." Note that we can find both *backups* and *ask edge*s between the scheme for argument from correlation to cause and the third factor question. In this case, we are not going to commit the fallacy of circular reasoning or begging the question because we don't appeal to the cited correlation but the other two correlations. For our example, let us imagine that the patient suffers from severe *abiosis* (nutrition disorder) and a hoarse voice. The medical experts have seen many people that suffer from both abiosis and a hoarse voice. Thus, they may conclude that abiosis is a cause of hoarse voice. This is a fallacious use of the scheme for argument from correlation to cause (**A_{10}**), and thus, the third factor critical question "is there a third factor that causes both abiosis and hoarse voice?" can be asked. We can also ask a more specific version of this question: "is larynx cancer a third factor that causes both the patient's abiosis and their hoarse voice?" In such a case, the positive answer, "yes, larynx cancer is the third factor" can be backed up using the argument scheme from correlation to cause: "*there is a positive correlation between larynx cancer and abiosis, thus larynx cancer is a cause of abiosis. And larynx cancer is also a cause of hoarse voice because there is a positive correlation between larynx cancer and hoarse voice. Therefore, larynx cancer is a third factor*" (**A_{11}**).

The coincidence question asks whether there exists any reason that establishes that the cited correlation is any more than a coincidence. This question is CQ_3 for the scheme for argument from correlation to cause. In order to disprove that the cited correlation is mere coincidence, we should prove that the correlation is a real causal relation, and this means that we may be able to apply the schemes for argument from correlation to cause and abductive argument to back up the answer to the coincidence question. However, the argumentation scheme from correlation to cause cannot be used as such since it causes us to commit the fallacy of circular reasoning or begging the question. In our example, we have constructed an argument by appealing to the correlation between old but healthy larynx cancer patients and the absence of treatment risk from a hemi-laryngectomy (**A9**). Then, the coincidence question "Is there any reason to think that the correlation is any more than a coincidence?" (Walton et al. 2008, p. 329) can be asked. In order to support the negative answer to this question, we can construct an abductive argument whose conclusion indicates that there is no causal relation: "*Patient A (who also suffers from larynx cancer but is different from the patient under discussion) was not healthy and underwent the hemi-laryngectomy. The operation was successful and there was no risk to patient A. However, patient B (who suffers from larynx cancer and is also different from the former two patients) also had a hemi-laryngectomy, but he was very healthy. There was a risk for patient B. The best explanation for these facts is that patients' good health does not cause treatment risk, and thus the observed correlation is mere coincidence*" (**A12**).

The other event question, which is CQ_2 for the scheme for argument from sign, asks about the existence of "other events that would more reliably account for the sign" (Walton et al. 2008, p. 329) Here, the other event that can account for the sign under consideration may be a cause of the sign, and thus, we can prove answers to this question by constructing an argument using the correlation to cause or abductive argument schemes. Let us assume that the medical experts who oppose the hemi-laryngectomy procedure need to prove that the patient's health is not good. To do

so, they provide an argument from sign: "*his pulse rate is really high, thus, he isn't in good condition*" (**A13**). This argument is based on the implicit generalization that high pulse rate is a sign of poor health. In this case, the following is an appropriate other event question: "he exercised just a few minutes ago; does exercise more reliably account for his high pulse rate?" Answers to this question can easily be backed up using an argument that appeals to the correlation between exercise and high pulse rate (**A14**).

The property question, which inquires whether something definitely has the cited property, can be backed up using several argumentation schemes, including argument from sign, argument from witness testimony, argument from division, argument from composition, argument from verbal classification, argument from definition to verbal classification, argument from perception, and argument from memory. This critical question can be found in the list attached to the scheme for argument from verbal classification (CQ_1). In fact, Macagno, in his *means-end* classification of schemes, selected argument from sign, argument from verbal classification, argument from composition, and argument from division as the schemes that can be used to support the attribution of a factual property (2015, p. 197). Furthermore, we can apply the schemes for argument from composition or division to back up an answer to the property question because those schemes prove that something has a specific property based on the relation between the whole and its parts. We connect the scheme for argument from witness testimony to the property question (through a *backup edge*) since a witness, as a person who has experienced something happening, can attribute a property rather than making claims about the desirability of a course of action or a causal relation. For our example, suppose that, in order to prove that the patient is not in good condition, a medical expert constructs an argument from verbal classification: "*he is (should be classified as) an old man, thus he is not in good condition*" (**A15**). Then, "is he really old?" can be an archetypal property question. The expert can back up the positive answer to the question by constructing an argument from definition to verbal classification: "he is 75, which is over 60. So,

he is old" (**A_{16}**). This answer is based on the definition that one who is over 60 is old.

The hereditary question is about the divisional or compositional hereditariness of a cited property with regard to a certain aggregate. Argument from composition and argument from division share this question, since they are all based on the relation between the whole and its parts.

The difference and other case questions are CQ_1 and CQ_3 of the scheme for argument from analogy, respectively. The difference question is about the existence of a difference between two cases, while the other case question is about the existence of another case that is also similar to the former case and in which the cited proposition is false (Walton et al. 2008, p. 315). Since difference or similarity between two cases should be considered with regard to a certain property, if two cases share a property, we say that they are similar with respect to the property, and in contrast, if two cases have different properties, then we say that they are different with regard to those properties. Therefore, for the purpose of backing up answers to these questions, we can apply all argumentation schemes available for supporting the property question.

The truth question merely inquires whether the cited proposition is true in a given case. This question can be found in the list for the scheme for argument from analogy (CQ_2).

The assumption question is CQ_2 for the scheme for argument from verbal classification, which inquires whether the cited verbal classification is merely "based on an assumption about word usage that is subject to doubt" (Walton et al. 2008, p. 319).

The adequate definition and stipulative or biased definition questions apply to the scheme for argument from definition to verbal classification.

The progress, burden of proof, and proof strength questions apply to the scheme for argument from ignorance.

The poll and doubt questions apply to argument from popular opinion**.**

The action and ground questions apply to the scheme for argument from popular practice.

The expertise, **field**, **opinion**, **trustworthiness**, **consistency, and backup evidence questions** are the six critical questions for the scheme for argument from expert opinion. Other source-based arguments, like argument from position to know and argument from witness testimony, have some of these questions as can be seen in the figure.

To sum up, Fig. 4 involves 29 argumentation schemes and 39 critical questions. Among the 29 argumentation schemes, 6 schemes are thesis-independent, and the rest are thesis-dependent and can be applied only to specified critical questions. Furthermore, among the 39 critical questions, 18 have more than one thesis-dependent scheme that can be used to back up their answers, and the rest have no such schemes. We also put forward 16 arguments to illustrate the usefulness of our NASCQ.

6. NASCQ and complex arguments

A NASCQ can be used to construct and reconstruct, and then, in turn, evaluate complex arguments. Constructing and reconstructing complex arguments is one of the issues that has received significant attention in argumentation theory and informal logic (Freeman 1991, 2011; Hitchcock 2017; Walton 2006; Henkemans 1992; van Eemeren and Grootendorst 2004; van Eemeran et al. 2014; etc.). Hitchcock (2017) defined the notion of complex argument in terms of subordinate and superordinate argument. A subordinate argument is "an argument whose conclusion is a premiss of another argument" (Hitchcock 2017, p. 455) while a superordinate argument is "an argument with a premiss that is the conclusion of another argument." (Hitchcock 2017,p. 455) Therefore, a complex argument is a chain of simple arguments, that is, "a set of two or more simple arguments each of which is either superordinate to or subordinate to at least one other argument in

the set, and one of which (the main argument) is not subordinate to any other argument in the set" (Hitchcock 2017, p. 455).

Since every scheme is useful for constructing and reconstructing simple arguments and a complex argument is a chain of simple arguments, we should also construct or reconstruct complex arguments by means of a chain of argumentation schemes. We call such a chain of argumentation schemes, which captures the internal structure of a complex argument, a *scheme chain*. But how can such a scheme chain be created? How should we connect schemes in such a scheme chain? Generally, if a chain is to be strong, every link should be connected with another proper link, not an arbitrary one. Similarly, in a scheme chain, every scheme should be connected with another scheme that is suitable for providing it with a proper premise.

In a complex argument, the conclusion constitutes a premise for another argument. Therefore, it is self-evident that a scheme chain should have a scheme that is supported by another scheme involved in the chain, that is, a scheme whose premise is supported by another scheme involved in it.

The most important thing is that the positive answer to a critical question attached to a scheme can be counted as a premise in that scheme. For example, Walton et al. (2008) proposed some new versions of the scheme for argument from expert opinion whose critical questions convert into *conditional* premises (Version Ⅱ and Ⅲ) (Walton et al. 2008, pp. 19-20) and, more remarkably, a version where every critical question is converted into an individual premise (Version Ⅳ) (Walton et al. 2008, p. 20). This demonstrates that the positive answer to a critical question is, in its essence, a premise of the scheme to which the question is attached. Furthermore, based on the fact that the positive answer to a critical question attached to an argumentation scheme can be a premise of that scheme, Gordon et al. managed to model critical questions in their Carneades argumentation system (2007, pp. 887-888). More interestingly, every real and ordinary premise of a scheme can be the positive answer to a critical question attached to the scheme, since it is possible for the scheme to have a critical question that

merely asks whether a premise of the scheme holds[10] (Verheij 2003). For instance, the major premise of the scheme for argument from expert opinion is the positive answer to the *field* question, whereas the minor premise is the positive answer to the *opinion* question.

To sum up, the answers to all of the critical questions attached to a scheme can be regarded as premises of the scheme. Moreover, in a scheme chain, which captures the internal structure of a complex argument, a scheme is connected to another scheme through a statement that is a premise of one scheme and the conclusion of the other. Therefore, it seems that in a scheme chain, a scheme is connected to another scheme through a critical question whose positive answer becomes a premise of one scheme and the conclusion of the other. Finally, a scheme chain can be defined as a set of two or more schemes, each of which has a critical question that is connected to another scheme or is connected with a critical question of another scheme and one that (the main scheme) is not connected with any critical question for any other scheme.[11] This shows that a scheme chain may, in fact, be part of a NASCQ. In other words, if all the schemes and critical questions involved in a scheme chain are also included in a NASCQ, all the connections between schemes and questions (both *ask* and *backup* edges)

[10] Such a critical question, which is used merely to question whether a premise of a scheme holds, is a question whose positive answer becomes Gordon et al.'s (2007) ordinary premise. This kind of critical question was first identified by Verheij (2003). Verheij noted that this kind of critical question is redundant, but Gordon et al. argued that it is necessary in a dialogue setting in order to distinguish different kinds of premises, including ordinary premises, and claimed that Verheij's account can only "make sense in a logical setting" (Gordon 2007, p. 879). It seems that, in this paper, we follow Gordon et al.'s (2007) account. Although the role of critical questions which merely ask whether a premise of a scheme holds cannot be neglected, such questions are not attached to some of the schemes in Walton et al.'s (2008) compendium, for example, the practical reasoning scheme. Therefore, we argue that critical questions of this kind should be attached to every scheme to build a more comprehensive NASCQ capable of capturing more complex arguments.

[11] This definition follows the pattern of Hitchcock's (2017) definition of a complex argument.

involved in the chain should also be included in the NASCQ.[12] Consequently, a NASCQ can be used to construct and reconstruct complex arguments. Every part of a NASCQ, which contains at least one critical question node and at least two scheme nodes, represents the pattern of reasoning to which a complex argument may conform. The positive answer to the critical question represented by a CQ-node becomes the conclusion of an argument and a premise of another in a complex argument structure.

For example, let us consider the following complex argument: "*We should perform a hemi-laryngectomy for the patient in order to cure his larynx cancer. He is in good condition.*" This complex argument is an instantiation of the scheme chain represented in Fig. 4: *Practical reasoning-Possibility question-Argument from cause to effect.* Such identification makes it possible to supply the missing parts of the complex argument and, in turn, to evaluate it. The structure of this complex argument can be analyzed by means of the scheme chain as follows (solid rectangles represent explicit propositions, while dashed ones represent implicit propositions):

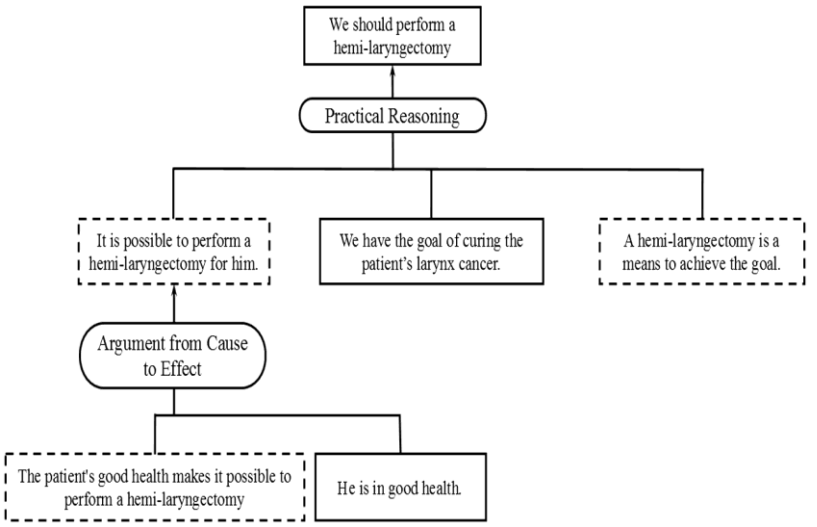

Fig. 5. Reconstructing complex arguments with a NASCQ

[12] The basic assumption behind this claim is that the NASCQ is *ideally comprehensive*; that is, it involves *all* possible connections that may exist between schemes and questions (both *ask* and *backup* edges) in real argumentation.

As shown in the figure above, the positive answer to the possibility question of practical reasoning (it is possible to perform a hemi-laryngectomy) becomes the proposition that connects two arguments involved in the complex argument; viz., it is the conclusion of one argument and a premise of the other. Such analysis carried out by means of the scheme chain teaches us that the complex argument has two missing premises and a missing conclusion. After identifying a scheme chain or a part of a NASCQ that captures the structure of a complex argument, the critical questions of all schemes involved in the chain can be asked, except for the question that connects the schemes.[13] In such a way, we can evaluate complex arguments in a dialectical setting as we normally do with simple arguments using argumentation schemes. Not only can we fill in the missing parts of a complex argument, but we can also construct complex arguments using a NASCQ.

In a dialectical setting, the proponent, who tries to back up the positive answer to a critical question asked by the respondent, in fact constructs a complex argument whose ultimate conclusion represents the thesis they are attempting to prove. Constructing complex arguments by means of a NASCQ without having asked any critical questions is *proleptic* in nature. To construct a complex argument, first the superordinate argument, which contains the ultimate conclusion, must be constructed using a specific argumentation scheme. Then, the proponent should construct a subordinate argument whose conclusion is a premise of the superordinate argument. The proponent should select a question from the critical questions attached to the scheme that the superordinate argument fits, whose positive answer is the premise they would support. Later, the proponent can construct a subordinate argument by applying a scheme associated with that critical question in the NASCQ. In such a way, the proponent can construct complex arguments by "*walking along the road"* of a NASCQ. This can be seen as proleptic since the proponent constructs subordinate arguments in anticipation of the critical questions the respondent will

[13] Merely asking the critical question that connects two parts of a complex argument is redundant because an answer to the question is already provided. However, we think it should not be seen as unreasonable to present another argument in favor of or against the answer provided.

ask (for more details about proleptic argumentation, see Walton 2008b).

7. NASCQ and formal argumentation

Recently, the field of AI has witnessed growing research interest in formal argumentation due to its explanatory power and its capacity to handle inconsistency. Most formal argumentation mechanisms are based on Dung's (1995) landmark work on *abstract argumentation framework* (AF), which consists of a set of arguments and the binary attack relations between them. *Semantics* is used as a criterion for identifying acceptable arguments and drawing plausible conclusions. A set of arguments identified by semantics is called an *extension*.

It has been recognized that employing argumentation schemes in formal argumentation systems will help artificial agents improve their reasoning capability (Bex et al. 2003; Verheij 2003). Some attempts have been made to combine argumentation schemes with formal AFs (Gordon et al. 2007; Prakken 2010; van Gijzel and Prakken 2012; Atkinson and Bench-Capon 2008b). The basic idea behind those attempts is that we can capture the internal structure of arguments involved in an AF by means of argumentation schemes. Furthermore, it is also possible to characterize the relation between arguments as that of attack or support by means of critical questions.

An AF might be bipolar depending on whether it involves both attack and support relations or only attack relations (Cayrol and Lagasquie-Schiex 2013; Cohen et al. 2014). It has been shown that there exists both attack and support relations between arguments in everyday argumentation (Polberg and Hunter 2018). However, most argumentation semantics are defined in terms of attack, and bipolar AF should be converted into an equivalent mono-polar AF to apply semantics. If an AF allows for only simple arguments, the AF should be bipolar to consider all possible attacks and support relations between the arguments. If an AF allows complex arguments, the AF can consider all possible attack and support relations because any support relation can be included in a complex argument structure (Dung 1995). Since our NASCQ approach

makes it possible to reconstruct complex arguments, it can be applied not only to bipolar AFs but also to mono-polar AFs.

The NASCQ approach can, first of all, be adopted in argumentation-based decision support systems. In addition to getting justified answers, there is another benefit from modeling arguments and attacks with argumentation schemes and critical questions in Afs—such modeling can provide us with suggestions for exploring the critical questions that have not been assigned as an answer in order to make hidden assumptions explicit or to gather additional information about the case under discussion (Qassas et al. 2015, p. 288). Suppose that the argument "*his pulse rate is really high, thus, he isn't in good condition*" (**A**$_{13}$ in the example of section 5) is justified by an AF. The framework not only supplies the output proposition that the patient is not in good condition but also suggests looking into the likelihood of a causal relation existing between high pulse rate and poor health or looking into whether there are other events that could more reliably account for the high pulse rate because the other event and likelihood critical questions are attached to the scheme for argument from sign. Next, since in our NASCQ, the other event question is connected to the schemes for argument from correlation to cause and abductive argument, the framework can also suggest that additional information be gathered about the correlation between the observed other event and the sign or additional information that indicates which is better explained by the other event. Modeling every argument and attack with schemes and critical questions may also be associated with Shi et al.'s argument-based modal belief logic, which is based on a so-called *argumentation-support frame*, where every argument and attack is labelled by a set of propositions that it supports or attacks (2018).

Of course, it may be impossible to model every argument and attack involved in an AF by means of schemes and critical questions. However, if an analyzer manages to do so, then no recognized connection between schemes and critical questions should be arbitrary; instead, it should appear in a NASCQ, assuming that the NASCQ is complete—that is, it involves all the schemes and questions observed in the framework and all possible relations (both *asks* edges and *backup* edges) among them. For example, in

section 5, we built an AF which consists of 16 arguments and the attack or support relations among them. The figure below, wherein solid arrows represent attacks and dashed arrows represent supports, depicts the AF.

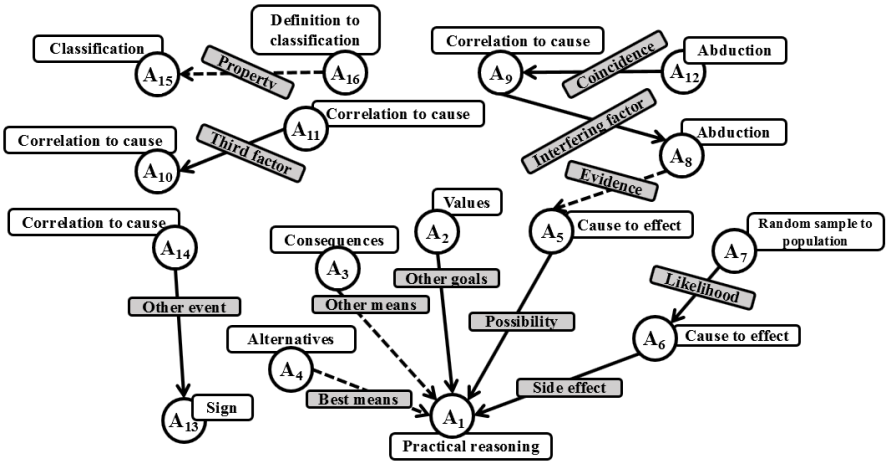

Fig. 6. NASCQ and AF

As shown above, every attack or support relation between two arguments is a relation between two schemes, which are bridged by means of a critical question in our NASCQ. For this reason, we can adopt a NASCQ for the sake of constructing arguments and establishing the attack or support relations among them. However, it should be noted that in order to make use of a NASCQ in such a way, one must ensure that it includes as many argumentation schemes and critical questions and possible relations as possible.

A NASCQ can also be used to improve argumentation in multi-agent systems (or in dialogue games). Argumentation schemes, as dialectical tools, can be employed in multi-agent systems where agents try to construct, analyze, and evaluate arguments. Some systems are capable of utilizing a single argumentation scheme (e.g. Atkinson and Bench-Capon 2007, 2008a) or a set of schemes (Wells 2014; Panisson et al. 2021). Now, it is time to introduce a NASCQ for multi-agent systems. Human arguers can construct arguments by '*walking along the road*' of a NASCQ, and so can artificial agents, who are not faced with the problem of memoriz-

ing a large and complicated NASCQ. Furthermore, even if the argumentation schemes of a NASCQ are repeatedly modelled, they do not give rise to circular arguments (Walton and Batten 1984).

Panisson et al. (2021) have devised an argumentation scheme-based argumentation framework that determines the acceptability of an argument on the basis of considering attendant critical questions in addition to Dung's (1995) *admissible* semantics. They say that an argument, instantiated from an argumentation scheme, can be an acceptable instance of that scheme only when all critical questions related to the scheme are answered positively (Panisson et al. 2021, Definition. 3, p. 364). Positively answering (or negatively answering when the agent wants to attack the argument) critical questions should result in the construction of further arguments that support the positive (or negative) answer to the question, and as a result, chained arguments are needed (Panisson et al. 2018, 2021). Then, a NASCQ can show the agents what reasoning patterns they are able to instantiate to positively (or negatively) answer a critical question.

In multi-agent systems, agents' construction of arguments should be based on dynamic, not static, knowledge bases. Therefore, agents' deliberation may shift to information-seeking where relevant facts are brought into play (Walton 2013a). A NASCQ can also be a useful tool for information-seeking and for updating an agent's knowledge base. Let us assume that an agent has constructed an argument by applying an argumentation scheme. In order to establish the acceptability of the argument, the agent should positively answer all of the attendant critical questions. However, if positive answers to the critical questions are not contained in the agent's knowledge base, then the agent may have to search for some relevant information. In such a case, a NASCQ, in which a set of argumentation schemes are attached to a critical question, will be of great help. For example, if an agent tries to seek information that is relevant to back up the positive answer to the *side effect* question of practical reasoning, then the associated schemes (argument from cause to effect, argument from sign, and all thesis-independent schemes) provide hints about what kind of evidence should be gathered: *the cause of the side effect is not*

given, there is no sign of the side effect, someone who is in position to know about the side effect said that there would be no such a side effect, or the side effect didn't occur in similar situations and cases.

One of the most ambitious and challenging projects of AI is *argumentation mining*, which is closely related to formal argumentation, computational linguistics, natural language processing, and other AI fields. Argumentation mining has been defined as the automated detection of the argumentation structure and the classification of both its component elements and their argumentative relationships (Moens 2018). The detection of argumentation schemes in natural language discourse is a crucial portion of the spectrum of argumentation mining because "argumentation schemes provide categories of arguments, together with criteria for recognizing them" (Macagno 2021, p. 294).

By utilizing a NASCQ, we are able to narrow down the scope of the search for schemes that correspond to an argument. It should be determined to which critical question in the NASCQ the conclusion of the argument applies. Then, of the argumentation schemes attendant to the critical question, the most appropriate one should be selected by considering the premises of the argument. For example, if the conclusion of an argument can be counted as an answer to the *side effect* question, then the instantiated argumentation scheme will be the scheme for argument from cause to effect, or argument from sign, or one of the thesis-independent schemes (assuming that the NASCQ in Fig. 4 is complete). The more argumentation schemes and critical questions a NASCQ involves, the more reliable the scheme detection engine we can build.

As the definition above shows, argumentation mining also includes the detection of relationships between arguments beyond the detection of schemes. It seems to us that revealing relationships between arguments is a relatively easy job because if one argument attacks/supports another, then they have a contradictory/common proposition. However, in everyday argumentation, an attack/support relation may exist between arguments even though they do not have any contradictory/common propositions. Consider the two arguments below (taken from our example).

Argument 1. A hemi-laryngectomy is a means to cure larynx cancer, so we should perform a hemi-laryngectomy on the patient.

Argument 2. The patient might suffer from low voice quality because a hemi-laryngectomy is one of the main causes of lowering voice quality.

It is obvious that the latter argument attacks the former, but they do not have any contradictory conclusions. A NASCQ can be of some help in a situation like this to detect attack/support relationships between arguments that have no contradictory/common propositions. After clearly identifying the argumentation schemes of two arguments, common critical questions (that appear both in the list of critical questions attached to the suspected attacker's/supporter's scheme [through *ask* edges] and the list of critical questions that the suspected attacker/supporter's scheme is attached to [through *backup* edges]) should be detected. If the conclusion of the suspected attacker/supporter can be reduced to a negative/positive answer to one of those common questions, then it can be declared that the arguments are in an attack/support relation. In the above example, the former argument is an instance of practical reasoning, and the latter is an instance of argument from cause to effect. In our NASCQ, practical reasoning is connected to 5 critical questions through *ask* edges, and argument from cause to effect is connected to 2 questions through *backup* edges. We can see that the *possibility* and *side effect* questions are shared by those two schemes. Furthermore, the conclusion of the latter argument is an instance of the negative answer to the *side effect* critical question of the former argument. Thus, it can be determined that the latter argument attacks the former. Here we should once again note that the more argumentation schemes and critical questions a NASCQ involves, the more reliable the argumentative relationship detection engine we can build.

8. Conclusions and future work

In this paper, we defined the new concept of a NASCQ. A NASCQ is a constellation of schemes, each of which is connected with another through the "*bridge*" of a critical question. Therefore,

two kinds of nodes and two kinds of edges are possible in a NASCQ. AS-nodes represent argumentation schemes, while CQ-nodes represent critical questions. The two kinds of edges are *ask edges* which go from a CQ-node to an AS-node and *backup edges* which go from an AS-node to a CQ-node. The critical question at the starting point of an *ask edge* can be asked against an argument fitting the scheme at the endpoint of the edge. Furthermore, the scheme at the starting point of a *backup edge* is applicable to back up an answer to the critical question at the endpoint of the edge. For example, in Fig. 4, five critical questions (the other goals, other means, best means, possibility, and side effect questions) are connected with the scheme for practical reasoning through *ask edge*s, and this means that these questions can be asked against an argument fitting the scheme. Two schemes (abductive argument and argument from correlation to cause) are connected to the side effect question through *backup edge*s, and this means that these schemes can be instantiated to construct an argument that backs up an answer to the question.

One of the important contributions of this paper is the distinction between thesis-dependent schemes and thesis-independent schemes. Thesis-independent schemes are applicable to back up answers to any critical questions, while thesis-dependent schemes are applicable only to certain questions. Such a distinction makes it easier to find possible candidate schemes to back up an answer to a critical question. Our distinction between thesis-dependent and thesis-independent argumentation schemes may also contribute to classifying a system of schemes.

As mentioned in the introduction, the NASCQ approach will be particularly useful for constructing an argument that attacks or supports the former argument. Once a proponent proves their own standpoint by putting forward an argument that supports the standpoint, the main concern of the proponent and the respondent is then to construct an argument that supports or attacks the former argument, respectively. To that end, both of them first identify the argumentation scheme that the former argument fits. Next, they try to construct an argument whose conclusion is the positive or negative answer to one of the critical questions attached to the scheme. Then, they can instantiate one of the argumentation schemes con-

nected to the critical question through *ask* edges in the NASCQ. By "*walking along the road*" of the NASCQ, both parties can proceed with their debate. We also showed that the NASCQ approach is instrumental in constructing or reconstructing complex arguments and formal argumentation frameworks.

In order to skillfully make use of a NASCQ, the users should memorize not only *scheme-question* connections but also *question-scheme* ones. This seems to vitiate the approach suggested in Hansen and Cohen's (2011) learner efficiency criterion for evaluating methods of informal logic. However, from another perspective, the NASCQ approach may increase learner efficiency since it provides a method for classifying and categorizing clusters of argumentation schemes and critical questions. How fast one masters the art of using schemes depends on the way they are classified and categorized as well as their number. As mentioned above, our approach makes it possible to unify similar critical questions that appear in different schemes and, in turn, reduce the number of critical questions. Furthermore, argumentation schemes can be grouped according to critical questions to which they can be applied, and this provides an easier way to memorize many schemes. For example, the schemes for practical reasoning, argument from consequences, need for help, distress, and waste are all connected to the other means question and thus connected to the possibility and side effect questions. This approach also has a broader scope since it is applicable to complex arguments as well as simple ones.

If it is going to serve the purpose of helping students and argumentation theorists construct and evaluate arguments, a NASCQ should be stored in a computer program.[14] Suppose that an argument is presented as the starting point of argumentation in a class on critical thinking or argumentation theory. The teacher can tell the students to ask some critical questions to evaluate the argument. A student may think "what questions should I ask?" In the

[14] In this paper, we do not explain the structural and algorithmic details of this kind of program not only because of space constraints, but also because it is beyond our aim. The aim of this paper is just to provide the theoretical ground for programming for such pedagogical purposes. Accordingly, we will turn our attention to developing such software based on a formal definition of NASCQ in future work.

case that the questions don't come easily to their mind, they can identify the scheme of the argument and click on its name on the program interface. The program will then display a set of possible critical questions attached to the scheme. The students can then ask proper questions in reference to the set. When an answer is given to a question, the teacher can ask "how can you justify your answer?" If a student is not sure how to craft an argument for their answer, they can click on the name of the question asked. Then, the program will display a set of possible argumentation schemes attached to the critical question. By instantiating any of these schemes, they can support the answer. Through such exercises, students can improve their skills for evaluating and constructing arguments.

Some students may ask an appropriate critical question that has not been stored in the program. In this case, the set of critical questions stored in the database should be updated. Similarly, a student may apply any new scheme to justification. Then the set of argumentation schemes should be updated. As a result, NASCQ will become more complete.

Our ambition is to build a NASCQ that involves all of the argumentation schemes that have been defined in the literature, but this is highly challenging since all possible relations between many argumentation schemes and critical questions should be carefully taken into account. Furthermore, argumentation schemes haven't been proposed by a single scholar but by many scholars, and each scholar provided their own definitions and classifications of the argumentation schemes.

Our future research task is to introduce a complete NASCQ into computer programs for teaching critical thinking and argumentation theory and various AI tools.

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