Chapter 8
Quality Argumentation and Epistemic Criteria

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The language of science is not exclusively the enunciation of terms and concepts, facts and laws, principles and hypotheses. The language of science is closely related to the restructuring character of scientific claims about method, goals, and explanations, a character firmly established in the history, philosophy and sociology of science (Duschl, 1994; Duschl & Hamilton, 1997; Hodson, 1985). Language of science is a discourse that critically examines and evaluates the numerous and at times iterative transformations of evidence into explanations (Duschl & Grandy, 2007). Thus, as this edited volume on argumentation demonstrates, educational researchers are focusing on ways to understanding the language of science and to support dialogic argumentation in science classrooms.

Shifting the dominant focus of teaching from what we know (e.g., terms and concepts) to a focus that emphasizes how we know what we know and why we believe what we know (e.g., using criteria to evaluate claims) requires a different classroom culture and discourse environment. Consider for a moment what's involved when science teaching and learning are framed around argumentation practices. First, scientific knowledge claims include information about theory (what knowledge is important), method (what strategies for obtaining and analyzing data are appropriate), and goals (what outcomes are sought and how can we determine if the outcome has been attained). A curriculum, instruction, and assessment design challenge is providing teachers and students with tools that help them build on nascent forms of argumentation to develop more sophisticated and rational scientific knowledge claims. Equally important, as Siegel (1995) argues, is the need to address the development of criteria students employ to determine the “goodness”, the normative status, or epistemic forcefulness of reasons for belief, judgment and action.

Engagement in argumentation discourse also requires appropriation of criteria and of evidence for the evaluation of arguments (Kuha, 1993) Driver et al., (1996). White and Fredericksen (1998) and Duschl (2000) each point to the importance of students seeing scientific inquiry as epistemological and social processes in which knowledge claims can be shaped, modified, restructured, and at times, abandoned. Thus, learners need to have opportunities to discuss, evaluate, and debate the processes, contexts, and products of inquiry. Such discussions and debates expose the members of the community to each others’ ideas, opinions, sources of evidence,
and reasoning. These discourse processes also make thinking visible to participants. Such visibility can, in turn, provide a powerful mediation or formative assessment opportunity. Herein lies the importance of locating robust argumentation frameworks that will provide the appropriate level of details for guiding the development of students’ argumentation practices. The feedback on thinking can come from the students themselves as well as the teacher. But it is the teacher that sets the agenda for mediating the learning environment that can support formative assessments on pupils’ scientific thinking and reasoning. The challenge of teaching higher level thinking for teachers is fundamentally one of managing the ideas and information that are generated by students (see Zohar, this book).

The adoption and development of argumentation frameworks has gained in importance over the last two decades as researchers and curriculum developers seek ways to either nurture dialogic discourse in classrooms or to analyze the development of students’ reasoning with evidence and theory. When looking across the various available options for argumentation frameworks one sees that there are issues regarding the “grain size” of information being sought and used (Sampson & Clark, 2006; Duschl & Osborne, 2002). Toulmin (1958), for example, distinguished between field-dependent and field-independent forms of argumentation with the latter focusing on the general patterns of arguments involving claims, warrants, backings, rebuttals, qualifiers and conclusions. The question asked by Sampson and Clark (2006) in a review of 5 different frameworks for examining rhetorical argumentation is “How does any framework inform us about the quality of students’ argumentation?” This is an important question and one that is taken up in this chapter. Specifically, argumentation while common among many cultures and communities, when played out in science argumentation discourse has particular rules for “what counts” for knowledge building. Such knowledge building rules represent the epistemic demands (Sampson & Clark, 2006), epistemic resources (Hammer & Elby, 2003), epistemic actions (Pontecorvo & Girardet, 1993) and the practices of epistemic communities (Duschl & Grandy, 2007). Thus, as stated above, when thinking about argumentation discourse in classrooms, there is a need to have tools that can support or scaffold students’ participation in argumentation discourse and, importantly, teachers’ assessment of the students’ argumentation.

Sampson and Clark (2006) review 5 frameworks used for the assessment of argument:

- Toulmin’s Argument Pattern in science education research (Erduran et al., 2004; Jiménez-Aleixandre et al., 2000; Kelly et al., 1998);
- Zohar and Nemet’s modification of Toulmin (Zohar & Nemet, 2002);
- Kelly and Takao’s framework examining the epistemic status of propositions (Kelly & Takao, 2002; Takao & Kelly, 2003);
- Sandoval’s framework for examining the conceptual and epistemic quality of arguments (Sandoval, 2003; Sandoval & Millwood, 2005); and
- Lawson’s framework for examining the hypothetic-deductive validity of arguments (Lawson, 2003)

There remain concerns about the quality of argumentation and reasoning that can emerge if more refined epistemic criteria are not introduced to students. Sampson and Clark proposed 5 criteria for examining the quality of scientific arguments (pp. 658–660):

1. Examine the nature and quality of the knowledge claim—analytical methods should focus on the types of claims made by students and the ability to coordinate claims with available evidence.
2. Examine how (or if) the claim is justified—students need to learn to provide empirical evidence but also need to learn what kinds of evidence are needed to warrant an argument.
3. Examine if a claim accounts for all available evidence—students tend to not focus on the patterns in data but rather give priority to single pieces of evidence that support personal beliefs.
4. Examine how (or if) the argument attempts to discount alternatives—more than one claim may be an acceptable explanation for a phenomenon, students need to learn how to challenge weaknesses in alternative explanations.
5. Examine how epistemological references are used to coordinate claims and evidence—students need to learn how to justify/evaluate the ways evidence is gathered and interpreted, students do not examine the design of investigations or the methods used to obtain evidence.

A promising framework not reviewed by Sampson and Clark is Walton’s (1996) argumentation schemes for presumptive reasoning. My claim is that the Walton framework can help address most of the 5 criteria put forth by Sampson and Clark. The theoretical framework for the adoption of argumentation discourse that is presented in the next section is developed from three studies employing 9 of Walton’s categories to examine student discourse. The initial study to use Walton categories (Duschl et al., 1999) was grounded in an evaluation of Project SEPIA. Sibel Erduran and I worked on the design, piloting, and implementation of the group interview protocols. Sibel Erduran conducted the group interviews. Kirsten Ellenbogen and I coordinated and implemented the analysis of the group interviews. The Walton analytical scheme was also used to analyze discourse first in a study of computer-supported classroom science learning (Goldman et al., 2002); and second in a study of argumentation discourse used in extended writing
responses on A-level course examinations (Osborne et al., 2002) In the rest of this chapter, I will describe the use of Walton’s framework for the assessment of middle school students’ argumentation. First I will provide a rationale for the theoretical background to the research programme, Project SEPIA, that has led to the design of learning environments to support argumentation in middle school science classrooms.

Theoretical Framework on Argument

A trend in science education is the move away from the implementation of discrete single lessons that seek outcomes related exclusively or predominately to students’ concept learning regarding facts and principles. There is now focus on knowledge use with an emphasis on the coordination of evidence and explanation or of observation and theory (NAEP, 2006). Traditionally, science education learning goals have oscillated between content and process emphases. New understanding of learning derived from the learning sciences (Bransford et al., 1999; Duschl et al., 2006; Pellegrino et al., 2002; Sawyer, 2006) are emphasizing the importance of supporting the development of complex reasoning among learners. According to Bransford et al. (1999) research over the past 30 years has contributed five themes that have changed our conceptions of learning:

1. Memory and Structure of Learning—how learners develop coherent structures of information;
2. Analysis of Problem Solving and Reasoning—how learners acquire skills to search a problem space and then use these strategies;
3. Early Foundations—assessing infants’ early learning is causing us to rethink the skills and abilities children bring with them to school;
4. Metacognitive Processes and Self-regulatory Capabilities—how learners engage in self-monitoring and executive control of one’s performance;
5. Cultural Experience and Community Participation—how learners become attuned to the constraints and resources, the limits and possibilities, that are involved in the practices of communities.

In science education, the development of reasoning often has an evaluative component with respect to the examination of evidence and explanation. New policies speak to the importance of instructional contexts that seek outcomes related to students’ reasoning and communication in science contexts. In the United Kingdom, the policy recommendations in the document Beyond 2000 (Millar & Osborne, 1998) suggest formulating science instruction such that goals relating to a public understanding of science and ideas-about-science are addressed and not squelched by concept learning. In the USA, the National Science Education Standards (NRC, 1996, 2001) make Inquiry, Unifying Themes and Principles, Science in Social and Personal Perspectives and Nature of Science four of the eight content goals. In short, the message internationally evidenced by other worldwide policies in science education (Jiménez-Aleixandre & Erduran, this book) is that there is more to science learning than knowing facts and principles. The message is that in addition to a focus on students’ learning about what we know, science education needs to also focus students’ attention on how we know what we know and why we choose to believe it over alternatives. The how and why focus requires adoption of dialogic discourse processes, of which argumentation is a part, in order to engage learners in the epistemic practices involving the selection of evidence for the development of scientific explanations.

Argumentation has three generally recognized forms: analytical, dialectical, and rhetorical (van Eemeren et al., 1996). Analytical arguments are grounded in the theory of logic and include, as examples, material implications, syllogisms, and fallacies. Essentially in the analytical approach an argument proceeds inductively or deductively from a set of premises to a conclusion. For analytical arguments of categorization, the form is the syllogism: All men are mortal; Socrates is a man; Therefore, Socrates is mortal. For analytical arguments of causation, the form is material implication: If p then q; p; Therefore q.

Dialectical arguments are those that occur during discussion or debate and involve reasoning with premises that are not evidently true. Dialectical arguments are a part of the informal logic domain. Rhetorical arguments, on the other hand, are oratorical in nature and are represented by the discursive techniques employed to persuade an audience. In contrast to the other two forms of argument where the consideration of evidence is paramount, rhetorical arguments stress knowledge of audience. In science, there is general agreement that all three forms of argument are used as theories are refined and justified but dialectical and analytical owing to the focus on evidence are more exacting and representative of high quality scientific argumentation.

Designing learning environments to facilitate and promote argumentation is a complex problem given that the discourse of science involves the three different forms of argumentation. The central role of argumentation in doing science is supported by both psychologists (Kuhn, 1993) and philosophers of science (Sieg, 1995). Argumentation is seen as a reasoning strategy and thus also comes under the general reasoning domains of informal logic and critical thinking as well.

Given the wide use of Toulmin’s Argument Pattern (TAP) (Toulmin, 1958) as a model of evidence-to-explanation transformation process, some further exploration is warranted. A generic representation of the TAP discourse model from data to conclusions is depicted in Fig. 8.1. Toulmin posits that the quality of an argument can not be judged by form alone (e.g., modus ponens, modus tollens, material implication). Rather, the content and context of an argument (i.e., the evaluation of arguments as they occur in practice) are critically important for determining what counts as data, warrants, and backings. For this reason, Toulmin introduced the idea of argumentation field. The field frames the content for the argument. Thus, the content of an argument will be composed of both field-dependent and field-independent elements.
of "appeals to"-type argumentation moves are put forth. Of these, 9 were judged to be relevant to features of middle school science classroom discourse (see Table 8.2). The rationale for using Walton’s scheme is that if the goal is to improve students’ scientific reasoning, then a more nuanced and detailed framework is needed to monitor and guide how students are employing evidence in the construction of explanations. The Walton schemes for presumptive reasoning, I believe, provide such details.

The adoption of the Walton presumptive reasoning schemes facilitates employment of frameworks for the analysis of argumentation discourse in science classrooms. Dialogue logic occurs during dialectical argumentative exchanges, like that which occurs during collaborative small group science investigations and assessment conversations (Duschl & Gitomer, 1997) as well as asynchronous computer-supported communication environments. During a dialogue a proponent may carry any number of changing commitments as the burden of proof shifts during an exchange. In a dialogue context, the sources of evidence employed to shift burden of proof are much more extensive than those employed in analytical contexts. Rescher (1976, 1977), and more recently Walton (1996), maintain that dialectical argumentation is grounded in burden of proof, presumption, and plausibility. Walton (1996) defines presumptive reasoning as that reasoning which occurs during a dialogue when a course of action must be taken and all the needed evidence is not available. Such reasoning is not based solely on knowledge and probability but instead focuses on shifting presumption (e.g., burden of proof) onto the other dialogue participants. Such a scenario of reasoning from a partial set of experiences and evidence reflects quite well what typically occurs in middle school science classrooms.

A Study of Argumentation Discourse in Middle School Science Classrooms

The next sections of the chapter report the initial research study (Duschl et al., 1999) that assessed the quality of argumentation by students participating in SEPIA classrooms using Walton’s framework for presumptive reasoning. First, a brief overview of the SEPIA instruction and assessment models is provided. Next, is a section on methods and data sources used in the study. Here the discussion reports on efforts to initially try and use TAP with "Appeals to" categories as the analytical framework. Owing to difficulties presented above, TAP was abandoned and Walton adopted as the analytical framework for discourse coding. Results are then presented followed by a last section that discusses conclusions of the study and implications for the use of frameworks that seek to quality argumentation by promoting consideration of epistemic criteria.
SEPIA—Science Education through Portfolio Instruction and Assessment

The design of SEPIA curricula is a blending of guidelines from cognitive psychology and philosophy of science (Duschl & Gitomer, 1991; Gitomer & Duschl, 1995; Goldman, et al., 2002). A general goal is to develop scientific reasoning. The specific goals are to develop students’ ability to reason about explanations, experiments, and models. Three units were developed, Vessels with the epistemic goal of evaluating causal explanations; Acids & Bases with the epistemic goals of evaluating chemical models; Earthquakes & Volcanoes with the epistemic goals of evaluating scientific arguments. Many years into the effort, the teachers, researchers and advisors working on Project SEPIA are well aware that the approach proceeds from five key features:

1. The topic of investigation is an authentic question or problem that has some consequence to the lives of the children
2. Conceptual goals are kept to a limited number so as to facilitate an understanding and adoption of epistemic criteria that assess the accuracy and objectivity of knowledge claims
3. Assessment of students’ understandings and ideas proceeds from assignments that are designed to produce a diversity of outcomes
4. Both the criteria for the assessment of students’ products and performances and the products and performances themselves are publicly shared employing a direct teaching discourse strategy labeled an ‘assessment conversation’
5. The depth of student understanding is assessed and communicated employing a portfolio process

The principal focus for SEPIA units is on epistemic goals as learning outcomes. Such goals seek to develop students’ understanding of the structure of knowledge for the purposes of proposing and evaluating knowledge claims grounded to the evidence from the inquiry. Hence, epistemic goals seek to establish the criteria or rules upon which decisions and choices are made, for example, “what counts”. Epistemic goals establish the ground rules to construct and evaluate scientific arguments, scientific explanations, models or theories, scientific experiments and scientific hypotheses.

Methods and Data Sources

Seventeen triads of middle school students participated in a structured 45–60 minute long interview. The task for the group was to review and then provide constructive feedback for the improvement of a science fair project. Students were seated in front of the science fair poster—a three panel cardboard presentation on buoyancy and flotation including pictorial representations of the investigations done by a 7th-grade student. Interview protocols were designed, reviewed, piloted and revised. There were three components of the interview. First, a warm-up activity that involved students cooperatively constructing tangram figures was used. This was done to encourage group work and group decision-making in particular. Second, a set of open-ended questions focusing on the format and content of the science fair project were presented. This was done to focus attention on the parts of the project showing the data table, the hypothesis being tested, the methods used and the conclusion statement. Finally, a set of questions focusing on the evidence and the claims made in the science fair project were presented to students. All sessions were video-taped, audio-taped and then transcribed. Transcripts of the sessions were reviewed for accuracy. The analysis below only examines the last (or third) section of the structured group interview for it is here that the use of epistemic criteria was most likely.

Analysis of the group was the method of inquiry for the present study. Two argumentation schemes were trialed for the analysis of student discourse—Toulmin’s argument scheme and Walton’s argumentation schemes for prescriptive reasoning. But in the end, for reasons described below, only the Walton schemes were used. The application of Toulmin’s model followed closely the procedures adopted by Pontecorvo and Girardet (1993) in a study of children’s group reasoning in the context of examining history book passages. These authors first analyzed the frame of discourse which identifies the general orientation of the discussion. The second level of analysis examines “reasoning sequences” in which particular epistemic actions are pursued. The final unit of analysis was the “idea unit”. Each idea unit was submitted to a double categorization (see Table 8.1). At the first stage, the unit was assigned to an argumentative operation and then it was assigned to an epistemic operation.

For the “Appeal to” category the following list of options was provided by Pontecorvo and Girardet: analogy, exemplar cases or instances, conditions, rules or general principles, motives/intentions/goals, consequence/implications, authority.

<table>
<thead>
<tr>
<th>Table 8.1 Operations used by Pontecorvo and Girardet (1993)</th>
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</thead>
<tbody>
<tr>
<td><strong>Argumentative operations</strong></td>
</tr>
<tr>
<td>Claim – Any clause that states a position</td>
</tr>
<tr>
<td>Justification: Any clause that furnishes</td>
</tr>
<tr>
<td>adequate grounds or warrants for a claim</td>
</tr>
<tr>
<td>Concession: Any claim that concedes something</td>
</tr>
<tr>
<td>to an addressee, admitting a point claimed in</td>
</tr>
<tr>
<td>the dispute</td>
</tr>
</tbody>
</table>
(expert, author, source), time, sociocultural context, spatial temporal context. Here we can see an extension of claims, warrants and backings by, in particular, the use of the "Appeals to" category.

Nine of the 25 argumentation schemes proposed by Walton were selected for the second analysis. The selected schemes are presented in Table 8.2. As you will note there is some overlap between Walton's categories and Pontecorvo and Girardet's "Appeal to" categories. The difference is that we applied the 9 categories to the reasoning sequence or larger chunks of conversation, a level above the idea unit used by Pontecorvo and Girardet.

### Results

In contrast to the success Pontecorvo and Girardet (1993) had with applying Toulmin's argument pattern to analyze group reasoning in a history context, we found that the analysis of discourse employing argumentative and epistemic operations to the idea unit in our data on science students did not adequately distinguish signal from noise. First, the idea units did not work well with the argumentative operations. The argumentative operations were too broadly defined which led to a large assignment of sentences and statements to generic categories without adequately accounting for the diversity that existed within the category. Consequently, distinguishing the structure and patterns of argument was difficult. Difficulties were also encountered with the assignment and analysis of epistemic operations. The dialectical nature of the group interview made the assignment of analytic epistemic operations like definition, categorization, prediction, evaluation, warrants, and backings rather awkward. At times it felt as if square pegs were being forced into round holes. There was more success at assigning the epistemic operations to the reasoning sequences than to the idea units.

The use of Walton's presumptive reasoning schemes more adequately fit the discourse structures (e.g., dialectical and rhetorical) and reasoning sequences of the group interview (see Table 8.3). Given the emphasis on dialogue, the appropriate unit of analysis was the reasoning sequence. The reasoning sequences is the conversation that takes place between group members when debating or argu-

### Table 8.2 Argumentation Schemes for Presumptive Reasoning (Walton, 1996)

<table>
<thead>
<tr>
<th>Argument from</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign</td>
<td>References to spoken or written claims are used to infer the existence of a property or occurrence of an event</td>
</tr>
<tr>
<td>Commitment</td>
<td>A claim that B is or should be, committed to some particular position on an issue, and then claims that B should also be committed to an action</td>
</tr>
<tr>
<td>Position to Know</td>
<td>An opinion A treats it as true or false</td>
</tr>
<tr>
<td>Expert Opinion</td>
<td>Reference to an expert source external to the given information</td>
</tr>
<tr>
<td>Evidence to Hypothesis</td>
<td>Reference to premises followed by a conclusion</td>
</tr>
<tr>
<td>Correlation to Cause</td>
<td>Infers a causal connection between two events from a premise describing a positive correlation between them</td>
</tr>
<tr>
<td>Cause to Effect</td>
<td>Reference to premises that are causally linked to a noncontroversial effect</td>
</tr>
<tr>
<td>Consequences</td>
<td>Practical reasoning in which a policy or course of action is supported or rejected because the consequences will be good or bad</td>
</tr>
<tr>
<td>Analogy</td>
<td>Used to argue from one case that is said to be similar to another</td>
</tr>
</tbody>
</table>

### Table 8.3 Adaptation of Walton's Schemes for Presumptive Reasoning

<table>
<thead>
<tr>
<th>Argument from</th>
<th>Definition</th>
<th>Look for...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign</td>
<td>References to spoken or written claims are used to infer the existence of a property or event</td>
<td></td>
</tr>
<tr>
<td>Commitment</td>
<td>Suggests action should be taken. A claims that B is, or should be, committed to some particular position on an issue, and then claims that B should also be committed to an action</td>
<td></td>
</tr>
<tr>
<td>Position to Know</td>
<td>There is insufficient information to make a judgment. Involves request for more information. A has reason to presume that B has knowledge of, or access to, information that A does not have</td>
<td></td>
</tr>
<tr>
<td>Expert Opinion</td>
<td>Reference to an expert source (person, text, group consensus, etc.) external to the given information. Supports a personal inference or point of view</td>
<td></td>
</tr>
<tr>
<td>Evidence to Hypothesis</td>
<td>Reference to premises followed by conclusion</td>
<td></td>
</tr>
<tr>
<td>Correlation to Cause</td>
<td>Often based on plausibility rather than probability</td>
<td></td>
</tr>
<tr>
<td>Cause to Effect</td>
<td>Reference to premises that are causally linked to a noncontroversial effect. Effect is an observable outcome, with no need for testing</td>
<td></td>
</tr>
<tr>
<td>Consequences</td>
<td>Practical reasoning in which a policy or action is supported/rejected on the grounds that the consequences will be good/bad. A statement about the value of the conclusion without any expressed concern for the properties nor the events that comprise the full argument</td>
<td></td>
</tr>
<tr>
<td>Analogy</td>
<td>Used to argue from one case that is said to be similar to another.</td>
<td></td>
</tr>
</tbody>
</table>
ing for, or against, a specific course of action or when evaluating a particular claim. There are multiple reasoning sequences in any given group discourse.

The scoring of the transcripts was carried out by six individuals trained to use the presumptive reasoning categories. Confusions among scorers between either one or the other related categories (e.g., Sign, Commitment, Position to Know) prompted us to collapsed categories (e.g., Request for Information and Inference) for purposes of the analysis. For example, when looking at students' discourse it was difficult to distinguish Cause to Effect from Consequence when the Effect (boat sinks) is a negative outcome. As a summary, the collapsed categories were as follows:

- Request for Information = Sign, Commitment, Position to Know
- Expert Opinion = Expert Opinion
- Inference = Evidence to Hypothesis, Correlation to Cause, Cause to Effect, Consequence
- Analogy = Analogy

Inter-rater reliability for the collapsed categories on two different transcripts was 90% and 84% respectively.

The broad array of presumptive reasoning schemes employed by students, such as Argument from Sign and Argument from Consequences, suggests that the authentic argumentative practices of students reflect a blending of analytical, dialectical, and rhetorical devices. There are two prominent patterns that emerge from the analysis of the data. The first pattern is that the SEPIA groups in comparison to the non-SEPIA groups engage in a higher frequency of dialogic argumentation schemes in all categories of presumptive reasoning. The second pattern is that the rank order of argumentation schemes displayed by SEPIA and non-SEPIA (i.e., the average number of arguments per student group per scheme) are the same. The data suggest that a developmental corridor for argumentation would begin with the dialectical structures or patterns and build toward the analytical structures or patterns.

Overall, the comparison between the average number of arguments per student group is 35 for SEPIA and 22 for non-SEPIA (Fig. 8.2). The data suggest that there is a treatment effect for SEPIA vs. non-SEPIA.

Although our small sample does not support statistical significance, several patterns in the data are noteworthy (Fig. 8.3). One pattern is the higher frequency of inference schemes (14 versus 9) being employed by SEPIA groups as compared to non-SEPIA groups. Another pattern is the slightly higher frequency of requests for information schemes (18 versus 13) for SEPIA groups.

The interpretation of the frequency data is seen as a positive indication that the curriculum, instruction, and assessment models that guide the design of SEPIA units are effective toward promoting presumptive reasoning discourse and do so in two important areas, for example, Requests for Information and Inferences. This in and of itself is not a surprising result given Duschl and Gitomer (1997) also report the success of SEPIA design features in getting students to communicate a diversity of ideas. What the results of the present suggest though is that there is a pattern of argumentation that the students employ. More importantly, the pattern is one that teachers and students could monitor and use to develop criteria for the evaluation of knowledge claims. For example, students can examine the arguments made and ascertain the kinds of evidence and premises being used or not used. An understanding of how students engage in argumentation can promote reasoning about reasoning (i.e., metacognition).

A second prominent pattern to emerge from the data is the similar ranking of argumentation schemes between SEPIA and Non-SEPIA students (Fig. 8.4). The rank correlation of argument schemes using the Spearman Rank Correlation Coefficient
is 0.95. Regardless of the students’ prior experiences with learning environments, the structured interviews around the science fair project stimulated presumptive reasoning discourse. Asking students to evaluate and then give advice on how to improve a product exposes the evidence and premises as well as the beliefs and assumptions that the students employ.

The high rank correlation reported in Fig. 8.3 is also seen as evidence that middle school age children have the cognitive and social tools to engage in presumptive reasoning on science topics. More specifically, the children are capable of employing a diversity of schemes with reference to an array of relevant evidence and premises. The data support Lemke’s (1991) claims about how discourse in science classroom can shift from conceptual to structural dynamics of language if the right context is provided.

**Conclusions and Educational Implications**

The analysis employing the Walton scheme demonstrates that individuals bring a great deal more to argumentation than are identified by strict analytical logical schemes or rhetorical schemes like Toulmin’s Argument Pattern. Such refinements help provide frameworks for getting at the five criteria set down by Sampson and Clark (2006). Argumentation frameworks that employ more refined categories or “Appeals to” structures offer productive pathways for researchers to examine the quality of argumentation in terms of epistemic criteria. Argumentation of students’ discourse to promote critical thinking and reasoning would benefit by a shift from an emphasis on deductive and inductive argumentation schemes to an initial emphasis on the more natural dialogue logic found in dialectical contexts. Interventions in the form of formative feedback from teachers as well as engage-
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