DOCUMENT RESUME

ED 453 050		SE 063 912

AUTHOR	Duschl, Richard A.; Ellenbogen, Kirsten; Erduran, Sibel
TITLE	Promoting Argumentation in Middle School Science Classrooms: A Project SEPIA Evaluation.
PUB DATE	1999-03-00
NOTE	19p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Boston, MA, March 28-31, 1999).
AVAILABLE FROM	For full text: http://www.educ.sfu.ca/narstsite/conference/duschletal/duschletal.html.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Concept Formation; *Curriculum Design; Discovery Learning; Educational Environment; Evaluation Methods; Foreign Countries; Inquiry; *Learning Processes; Middle Schools; *Persuasive Discourse; Science Education
IDENTIFIERS	Learning Environment

ABSTRACT

Effective argumentation is the distinguishing feature of a classroom that employs discovery teaching and student inquiry methodologies. In the long term, the objective of the program is to understand how to design learning environments and curriculum, instruction, and assessment models that promote student self-reflection. The study evaluates the effectiveness of the Science Education through Portfolio Instruction and Assessment (SEPIA) curriculum-instruction-assessment learning environment design features in developing learners' abilities to reason about and evaluate scientific claims. (Contains 38 references.) (YDS)

Promoting Argumentation in Middle School Science Classrooms:

A Project SEPIA Evaluation

Richard A. Duschl, Kirsten Ellenbogen, Sibel Erduran

Department of Teaching & Learning

Peabody College-Vanderbilt University

Introduction

A trend in science education is the move away from the implementation of lessons that seek outcomes related exclusively or predominately to studentsí concept learning. While the traditional alternative for concept learning has been process learning, newer ideas and beliefs in cognitive and social psychology speak to the importance of instructional sequences/units that seek outcomes related to studentsí reasoning and communication in science contexts. Recognizing that science education is more than concept learning, forward thinking policies and recommendations are advocating learning how to do science and learning about the nature of doing science (Hodson, 1992; NSES, 1996). In the United Kingdom, the policy recommendations in the government document Beyond 2000 are to format science instruction such that goals relating to a public understanding of science are addressed and not squelched by concept learning.

Research on learning and the implications it has for the design of learning environments (Glaser, 1994) strongly suggests that concept learning take place in a context that also supports the development of tools, criteria, standards, and rules students can use to investigate, represent, communicate, assess, and evaluate knowledge claims. Peter Fensham (1988) has made a similar argument to shift the focus of science education in his historical review of 20th century science education curriculum development. His position is that the almost exclusive emphasis on the conceptual goals of science has depleted science education of its cultural and social contexts. The language of science is not exclusively the enunciation of terms and concepts, facts and laws, principles and hypotheses. The language of science, owing 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), is a discourse that critically examines and evaluates the numerous and at times iterative transformations of evidence into explanations.

Review of the Literature

Focusing on the goal of developing studentsí habits of mind that facilitate both an ability to construct scientific knowledge claims as well as to evaluate the claims constructed, researchers (Brown, Collins, & Duguid, 1989; Duschl, 1998; Krajcik, et al, 1994; Penner, Lehrer, and Schauble, 1997; Roth, 1995; White & Frederickson, 1998) have begun to focus attention on the need for learners to engage in sustained long term inquiries. Long-term inquires, full inquiries, or as Schwab called them ëinvitations to inquiry,í create affordances for several kinds of learning that shorter discrete lesson formats do not. Specifically, the long term inquiries create opportunities for learning to focus on the conceptual, notational, and epistemological dimensions of reasoning and communicating in a knowledge domain (Gardner, 1991). Or, as stated above, concept learning can be situated in a context that also supports the development of language, tools, criteria, standards and rules students can use to investigate, discover, represent, communicate, assess, and evaluate knowledge claims.

Hence a concomitant goal for the development of instructional units is to facilitate formative assessment opportunities. The ability of teachers and researchers to understand how to move learners along in the development and acquisition of conceptual, notational, and epistemological knowledge is seen as paramount to educational improvements (Black & Wiliam, 1998).

The design of science learning environments that support the development of learning science reasoning and appropriation of tools and language for doing science are frequently situated in task environments that require epistemic reasoning. Penner, Lehrer, and Schauble (1997) used models and model building as the epistemic context for coordinating the curriculum, instruction and assessment frameworks on investigations about the structure and function of the elbow. Duschl and Gitomer (1997) in research on portfolio assessment strategies coordinated curriculum, instruction, and assessment frameworks around the construction and evaluation of causal explanations for vessels floating with and without loads. Schauble, Glaser, Duschl, Shultz, and John (1995) report significant changes in studentsí representations of the purposes for experiments employing the same epistemic context of causal explanations for floating vessels. Other research that points to the positive effects of engaging students in metacognitive reasoning in epistemic contexts include White and Frederickson (1998).

Here, then, at the level of making decisions about ëwhat countsí is where we want to claim science is properly done and, subsequently, where classroom discourse and assessments should focus. When the goal of instruction is engaging students in scientific inquiry and when the organization of curriculum, instruction, and assessment models provide students with opportunities and encouragement to develop, report, evaluate, revise, and defend choices, as well as provide teachers with opportunities to capture, monitor and assess student ideas, epistemic contexts will soon dominate classroom discourse. In particular, when students are provided opportunities to develop and revise, challenge and defend a scientific claim, our observation is that wide ranging conversations in small groups and in whole class take place, a diverse reporting of ideas occurs in student reports, and, very importantly, a shift in authority from textbook and teacher to evidence and students can be seen (Duschl & Gitomer, 1997; Jimenez-Aleixandre, et al, 1997; Penner et al, 1997; Roth, 1995) . Under such conditions, the role of the teacher becomes one of facilitation and, perhaps more importantly, one of provocateur or discovery teacher.

Hammer (1997), studying his own teaching in a physics class, asserts that successful teaching begins with a set of planned observations and ideas but involves unplanned divergences brought about as students engage in meaningful learning. Successful instruction, according to Hammer, is dependent on the teachersí unanticipated perceptions and insights of studentsí needs and meanings. Such curriculum-in-the-making teaching he refers to as ëdiscovery teaching.í

The design of science learning environments that promote ëdiscovery teachingí and student inquiries into the status of scientific claims is dependent on the incorporation and sequencing of activities and tasks that engage students in asking and debating ëwhat countsí and ëwhatís the next move.í The science learning environment ought to provide teachers and students with opportunities for receiving information and providing guidance and feedback on such activities and tasks again, ëdiscovery teaching.í The idea of shifting the focus of science education to an assessment of knowledge claims is not a new one. Of particular note, is the work of the Patterns of Enquiry Project (Connelly, Finegold, Clipsham, & Wahlstrom, 1977). Here the emphasis is on developing students habits of mind, on the important role of discussion and argumentation, and on the need for enquiry to engage in an evaluation of knowledge claims.

Our hypothesis is that instructional models that emphasize the symbiotic-type relationship between evidence to explanation gives rise to patterns of discourse and reasoning quite different from traditional instructional models that emphasize the relationship between evidence and concept/process learning. Thus, a distinguishing feature of classrooms that employ the kind of instructional units described above will be the argumentation that occurs and the support teachers provide to nurture and facilitate argumentation.

The long term objective of our program of research is to better understand how to design learning environments and curriculum, instruction and assessment models that promote and facilitate student self-reflection about the status of knowledge claims, and, teacher feedback on studentsí argumentation strategies. The short term objective is to develop a methodological approach teachers and researchers can employ to understand and develop the argumentation strategies employed by learners.

The purpose of the present study was to evaluate the effectiveness of SEPIA curriculum-instruction-assessment learning environment design features in developing learnersí abilities to reason about and evaluate scientific knowledge claims. An experimental research design was employed to compare studentsí group argumentation discourse from both SEPIA and non-SEPIA.

Argumentation - The language of science

Quality teaching involves providing quality feedback to learners (Black & Wiliam, 1998). An area of feedback that is not well understood is assisting learners with arguing from evidence to explanation, or more generally, from premises to conclusions (Driver, Newton & Osborne, in press). Project SEPIA (Science Education through Portfolio Instruction and Assessment), represents an instructional approach where curriculum and assessment models are integrated to promote studentsí reflective reasoning and facilitate teachersí feedback on same. Given that the language of science involves the evaluation and justification of knowledge claims, research on the design of SEPIA units focuses on promoting and facilitating learnersí appropriation: (1) of core science concepts, and (2) strategies and criteria for reasoning about and evaluating the status of knowledge claims.

Argumentation has three generally recognized forms: analytical, dialectical, and rhetorical (van Eemeren et al, 1996). The application of analytical arguments (e.g., formal logic) to evaluate science claims is extensive and pervasive. The capstone event of applying argumentation to the sciences is perhaps Hemple-Oppenheimerís Deductive-Nomological Explanation Model wherein the argumentation form is used as an account to establish the objectivity of scientific explanations. Case studies of scientific inquiry, however, show that the discourse of science-in-the-making involves a great deal of dialectical argumentation strategies, too (Dunbar, 1995; Latour & Woolgar, 1979; Longino, 1994). Research in the sociology of science (Collins & Pinch, 1994) has also demonstrated the importance of rhetorical devices in arguing for or against the public acceptance of scientific discoveries. Cohenís (1995) position that argumentation as war is an ineffective metaphor for promoting discourse is one worth heeding. The alternative is to envision argumentation as a process that furthers inquiry and not as a process that ends inquiry. Thus, alternative metaphors for Cohen (1995) include: Argument is diplomatic negotiation, growth or adaptation, metamorphosis, brainstorming, barnraising.

Designing learning environments to both facilitate and promote studentsí argumentation, via design of the learning environment and teacher feedback, is a complex problem. The central role of argumentation in doing science is supported by both psychologists (Kuhn, 1993) and philosophers of science (Siegel, 1995; Suppe, 1998) as well as science education researchers studying the discourse patterns of reasoning in science contexts (Driver, Newton & Osborne, in press; Kelly, Chen, & Crawford, 1998; Kelly & Crawford, 1997; Lemke, 1990). Argumentation is seen as a reasoning strategy and thus also comes under the general reasoning domains of informal logic and critical thinking as well. Driver et al (in press) are correct in their assertion that we have much to learn about the dynamics of argumentation in science classrooms; particularly that which occurs among students when in groups.

To date, most investigations of student discourse have relied on the application of analytical forms of arguments (Kuhn, 1993) or Toulminís model for practical arguments (Eichinger, Anderson, Palincsar & David, 1991; Pontecorvo & Girardet, 1993; Kelley, Chen, & Crawford, 1998). In these studies, emphasis is placed on the structural features of arguments (i.e., premises, initial conditions, warrants, backings) and the empirical evidence presented to or employed by learners. Other promising approaches for studying discourse have used linguistic theory to analyze science talk (c.f., Gee, 1994; Lemke, 1990). A yet to be explored alternative avenue is that of employing dialog logic to the analysis of argumentation discourse in science classrooms.

Dialog logic occurs during dialectical argumentative exchanges, like that which occurs during collaborative small group science investigations, assessment conversations (Jimenez-Aleixandre, et al, 1997) and asynchronous computer-supported communication environments. The discourse is typically focused on one or more advocates positions. Argumentation schemes that focus on presumptive reasoning focus on the evidence and premises a person uses to shift the burden of proof from one advocate to another (Walton, 1996). Our analysis of small group discourse supports the use of presumptive reasoning as a framework to analyze students argumentation. Further justification and elaboration of presumptive reasoning as an analytical tool is provided in the next section. Given the design features of Project SEPIA learning environments, we hypothesized that if the curriculum was being effective according to design, then the argumentation discourse from groups of students in SEPIA classrooms would be significantly different from that of students, from the same class level and school, in non-SEPIA classrooms.

Methods/Data Sources

Seventeen triads of middle school students ó 11 SEPIA; 6 non-SEPIA ó 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 an actual science fair project prepared by a 7th grade student. Interview protocols were designed by the authors and reviewed by experts in both discourse analysis and cognitive psychology. The protocols were adapted, piloted with 5 triads of students in a different school system, and then revised into a final format. The final interview protocol is presented in Appendix A.

There are three parts to the interview. First is a warm-up activity that involves students in cooperatively constructing tangram figures. The tangram exercise helps to build group dynamics and put students at ease with one another and with the task. The second part of the interview involves a set of open-ended questions focusing on both the format and content of the science fair project. For the third part of the interview, the focus is on the evidence presented and the claims made in the science fair project.

Students were seated at a table that held an exact replica of the science fair project. The project was presented on the standard 3 panel cardboard and formatted according to standard science fair protocols; e.g., title, hypothesis, materials, data, results, conclusions. In order to aid the students in reading the numbers and graphs displayed, copies of the data and graphs were handed out to the students. All sessions were video-taped and audio-taped and then transcribed. Transcripts of the sessions were reviewed for accuracy. The present study only examines the last, or third section of the structured group interview. The last part of interview is where the epistemic context is richest.

Discourse analysis was the method of inquiry for the present study. The first level of analysis located the reasoning units in the discourse. A reasoning unit is a segment of discourse that involves dialog focused on a single factor or topic. More often than not, and not unsurprisingly, the reasoning units were aligned with the interview questions. Occasionally, however, the students would embark on topics tangential to the focus of the interview.

A search of the literature on argumentation led to the discovery of Waltonís (1996) <u>Argumentation</u>

Schemes for Presumptive Reasoning. Initial attempts to use Toulminís argument pattern for the analysis of discourse did not prove useful (Duschl, Ellenbogen & Erduran, 1999). The use of Waltonís presumptive reasoning schemes more adequately fit the dialectical structure of the group interview and the kind of evidence and premises students generate. Eight of the 25 argumentation schemes proposed by Walton were selected for the analysis of the reasoning units. The selected schemes are presented in Table 1. Given the emphasis on dialog, the unit of analysis was the reasoning sequence. The reasoning sequences is the conversation that takes place between group members when debating or arguing for, or against, a specific course of action or when evaluating a particular claim.

The scoring of the transcripts was carried out by 6 individuals trained to use the presumptive reasoning categories. Confusions among scorers between one or the other related categories (e.g., sign, commitment, position to know) prompted us to collapsed categories (request for information and inference) for purposes of the analysis. The collapsed categories are:

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 were 75% and 76% respectively.

Results/Conclusions

There are two prominent patterns that emerge from an analysis of the data. One 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. Two 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 rank correlation of argument schemes using the Spearman Rank Correlation Coefficient is 0.95. (See Figure 3)

Table 2 presents the results of the argumentation analysis employing all categories and Table 3 the collapsed categories. Overall, the comparison between the average number of arguments per student group is 35 for SEPIA and 22 for Non-SEPIA. The differences for both the complete categories and collapsed categories are presented schematically in Figures 1 and 2, respectively. The data suggest that there is a treatment effect for SEPIA vs. Non-SEPIA. Although our small sample does not enable us to report statistical significance, several patterns in the data are noteworthy. One is the higher frequency of inference schemes (14 to 9) being employed by SEPIA groups. Two is the slightly higher frequency of requests for information schemes (18 to 13) for SEPIA groups.

We interpret this frequency data as a positive indication that the curriculum, instruction, and assessment models that guide the design of SEPIA units are effective toward promoting argumentation discourse and do so in two important areas; e.g., requests for information and inferences. This in and of itself is not a surprising result, 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 students employ. More importantly, the pattern is one that teachers and students can 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).

The similar ranking of argumentation schemes between SEPIA and Non-SEPIA suggests to us the strength of the interview methodology we employed. Regardless of prior experience with learning environments that promote student discourse, the structured interviews around the science fair project stimulated argumentation discourse. Asking students to evaluate and then give advise on how to improve a product exposes the evidence and premises and beliefs and assumptions students employ.

The high rank correlation reported in Table 3 is also seen as evidence that middle school age children have the cognitive and social tools to engage in argumentation 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. Our data support Lemkeís (1991) claims about the how discourse in science classroom can shift from conceptual to structural dynamics of language if the right context is provided.

In addition to locating clear examples of argumentation schemes used by the students, we were also able to identify 4 sets of conversational dyads employing Waltonís scheme. There were naturally student-student and student-interviewer dyads. We also found two student-project: 1) student - ëproject as an objectí dyads and 2) student - ëproject done by a personí dyads. Reference to the science fair project by saying, stating, or reporting a claim (i.e., ëit saysí or ëit showsí) is an example of the project/object source. Reference to the individual who completed the project (i.e., ëhe should haveí) is an example of the project/person source. Based on the results of this experiment, the use of student science projects as a context for conducting clinical interviews about doing science and evaluation knowledge claims with students has promise as both a research tool and a context for instruction.

Educational Significance

The broad set of argumentation 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. The data suggest that a developmental corridor for argumentation might begin with the dialectical structures/patterns student employ naturally and build toward the analytical structures/patterns of discourse scientists employ. Interventions in the form of formative feedback from teachers as well as engagement in authentic tasks and activities that promote various genres of discourse that employ argumentation would seem to be important for moving students along the "talking science" continuum.

The analysis employing the Walton scheme demonstrates that individuals bring a great deal more to argumentation than are identified by strict analytical logical schemes. Presumptive reasoning analyses seem to be a natural entry point for the assessment and development of studentís argumentation strategies. Creating contexts and facilitating discourse that promote effective argumentation is a poorly understood element of science instruction. Augmentation of studentís 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 dialog logic found in dialectical contexts.

Future research needs to be carried out on the content of argumentation in natural settings like that in whole class, small group, and/or asynchronous computer contexts. Identification of the patterns of reasoning and argumentation schemes will facilitate and enrich our understanding of how to execute formative assessments of students reasoning from evidence to explanation.

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Appendix A

Protocol for SEPIA Student Interview

INTRODUCTION

Hello, my name is ____________. I'm from [Vanderbilt University]. You have been invited here today to help us learn more about how to teach and learn science. First we will do a warm-up task and then we will look at a student's science fair project.

WARM-UP ACTIVITY [Tangrams]

These are tangrams. They can be used to make familiar objects like this **[Point to picture on the table or to pictures in the book]**. Let's make this picture of a cat together. Would each of you please take two pieces. I'll start by putting this piece down. One at a time you are to place a piece. If you choose, you can also move just one piece. You can do this in any order - place then move or move then place. It is also okay to talk to each other , ask for help, or give advice. You will take turns putting pieces into the picture and continue until we have made a cat. Any questions?

[Put picture of cat on the table]

Tell me what part of cat you are making.

[Once students finish working with cat, state the following]

Very good job! That was very good!

SCIENCE FAIR PROJECT

LEVEL 1

Now, let's look at this science fair project **[turn panels around]**.

You have been invited here today as a group to give feedback on this science fair project.

A boy from another school did this project.

What advice would you give him to make it a better project?

This student did experiments with boats built out of aluminum foil.

Note, on the project these are called "vessels."

Here are some examples of the vessels used in the experiment **[point to vessels]**.

Here is a list of the materials that were used **[point to materials]**.

Here is a list of the procedures for doing the experiment **[point to procedures]** and the problem being solved **[point to problem]**.

Here are the data that were collected and the graph made from the data **[point to data and graph]**.

Here are the results **[point to conclusions]**.

The first thing I would like you to look over this project for a while and then to talk about your general feelings of it.

Once you finish discussing your impressions of it, then I'll ask some other questions.

[Allow students time to talk. Encourage all to participate. When a student uses a term (neat) ask what he/she means by neat. Ask for the reasons why. Ask follow-up questions]

Now I would like the group to consider some questions **[hand out questions one at a time and read aloud].**

ïBy looking at this science fair project, what can you tell about the person who did it? **[Place question on table]**

ïHow do you imagine the student did the work shown here on the poster? **[Place question on table]**

ïHow do you think the student did this science fair project? **[Place question on table]**

ïWould this display be helpful to your classmates learning science? Why? Why not? **[Place question on table]**

ïWhat does this project tell us about how we do science? (Is this good/accurate science?) **[Place question on table]**

[When they finish, state the following]

That was very good. Your discussion was very good. You have some very good ideas about how we can advise this student to make the project better.

SCIENCE FAIR PROJECT

LEVEL 2

What I would like the group to do now, is to judge this project in 4 categories.

What advice would you give to make this a better science fair project?

Discuss as a group what you would tell this student.

I will write it down here.

Here are the topics that you will consider.

[Place cards on table in a random order hand out the topics on cards and let students circulate them around].

Title/Problem

Materials/Procedures

Data/ Results

Hypothesis/Conclusions

These topics are from the science fair project **[point to the panel]**.

Here is the title and the problem **[point to title and problem statement on the panel]**.

Here is a list of the materials that were used **[point to materials]**.

Here is a list of the procedures for doing the experiment **[point to procedures].**

Here are the data and the results **[point to data and results]**.

Here are the hypothesis and conclusions **[point to hypothesis and conclusions]** .

To help you see it better, here are copies of what the student has written down.

[Pass out the handout]

You can start with any topic.

First decide which topic to begin with.

Remember, to think about advice you would give to help the student make this a better project.

As a group, you may talk about one of the topics, two of the topics, three of the topics or all four of the topics.

[Seek clarification of terms, probe for reasons, offer encouragement]

[When the students finish discussing and writing down their advice, state the following]

That was very good. Thank you. Your advice will be very helpful.

SCIENCE FAIR PROJECT

LEVEL 3

Now I would like you to think about some specific questions.

The first one is:

[Place card about 'load the vessel will carry']

<u>Read aloud - Topic 1: Title/Problem Statement</u>

What do you think the student meant by "the load a vessel can hold"?

What is it the student wanted to find out about the sides and surface of the vessel?

What do the letters vs in the title mean? Have you seen vs. used in other places?

What was the student trying to figure out?

Very Good

Here is the second set of questions:

[Place card about the 'Data Chart']

<u>Read aloud Topic 2: Materials/Procedures</u>

What can you say about the numbers/information presented in the "Data Chart"? How do the numbers/information help solve the problem of finding out if surface or sides is more important?

[Remind Students to look at handout]

Can you tell from this project what is most important - surface or sides?

Is there a winner between surface and sides? How do you know?

Here is the third set of questions:

[Place 'Hypothesis' card on the table]

<u>Read Aloud - Topic 3: Hypothesis/Conclusions</u>

Tell why you would agree or disagree with the following statements found in the conclusion:

My hypothesis was supported by the sides, surface, upthrust, displacement, buoyancy and gravity,

If a vessel is designed with higher sides and wider bottoms the more pennies (or load) it will hold. Therefore, upthrust and displacement causes a vessel to float.

[When the students finish answering the questions, state the following]

Thank you.

Now, would you like to add or make any changes to your list of advice?

[Place the list in front of the students]

[When students are done, state the following]

Thank you for helping us learn more about how to do science fair projects and how to teach science.

Table 1

Argument From	Definition	Look for...
Sign	Reference to spoken/written claims are used to infer the existence of a property or event.	References to the project. "look at this" "it shows"
Commitment	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.	Look for a request for action. "should.." "could..."
Position to Know	There is insufficient information to make a judgment. Involves request for more information. A has reason to presume that B has knowledge or access to information that A does not have.	Look for opposition statement.
Expert Opinion	Reference to an expert source (person, text, group consensus, etc.) external to the given information. Supports a personal inference or point of view.	"we did this before .." "the book says"
Evidence to Hypothesis	Reference to premises followed by conclusion. Includes a hypothesis ó a conjecture or generalizable prediction capable of being tested. (The hypothesis can come as part of the "if" or the "then" part of the argument.)	"I think..." "it looks like..." "it probably would..." "if it had..." "then it would"

Correlation to Cause	Infer a causal connection between two events. Characterized by an inferential leap, based on a natural law, but devoid of any reference to observational evidence.	(Often based on plausibility rather than probability.)
Cause to Effect	Reference to premises that are causally linked to a non-controversial effect. Effect is an observable outcome, with no need for testing.	" it will..."
Consequences	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 concerns for the properties nor the events that comprise the full argument.	"then it would be better" "itís basically good"
Analogy	Used to argue from one case that is said to be similar to another.	"like" or use of a metaphor

Collapsed Categories

Request for Information = Sign, Commitment, Position to Know

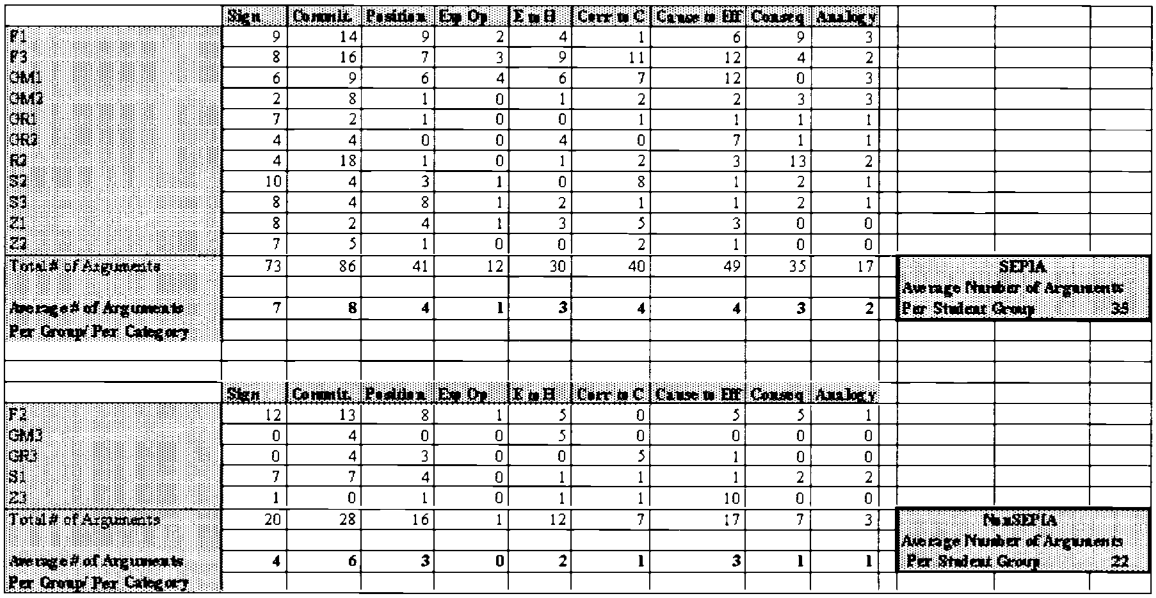
Expert Opinion = Expert Opinion

Inference = Evidence to Hypothesis, Correlation to Cause, Cause to Effect, Consequence

Analogy = Analogy

Table 2

Complete Data

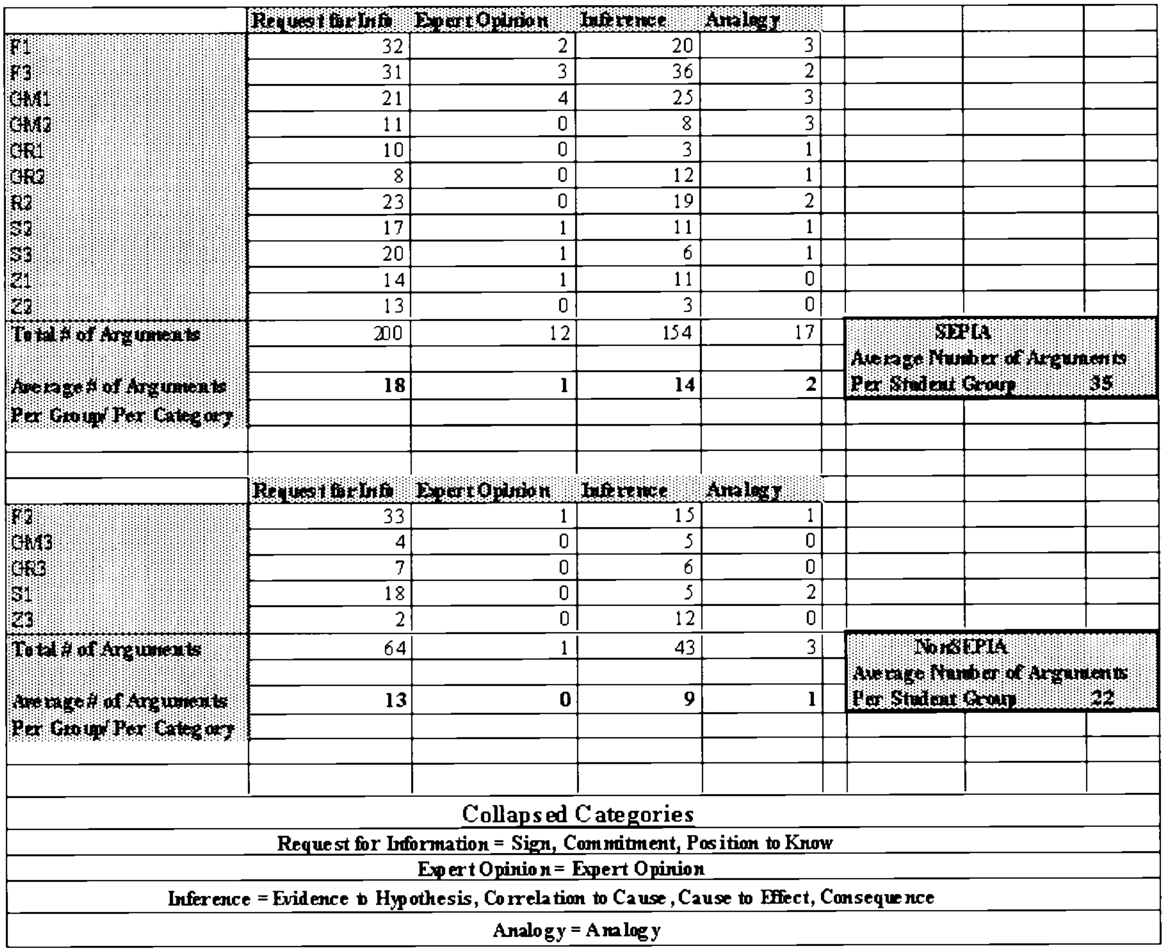


	Sign	Commit.	Position	Exp Op	E to H	Corr to C	Cause to Eff	Conseq	Analogy	
F1	9	14	9	2	4	1	6	9	3	
F3	8	16	7	3	9	11	12	4	2	
GM1	6	9	6	4	6	7	12	0	3	
GM2	2	8	1	0	1	2	2	3	3	
GR1	7	2	1	0	0	1	1	1	1	
GR2	4	4	0	0	4	0	7	1	1	
R2	4	18	1	0	1	2	3	13	2	
S2	10	4	3	1	0	8	1	2	1	
S3	8	4	8	1	2	1	1	2	1	
Z1	8	2	4	1	3	5	3	0	0	
Z2	7	5	1	0	0	2	1	0	0	
Total # of Arguments	73	86	41	12	30	40	49	35	17	SEPIA
										Average Number of Arguments
Average # of Arguments Per Group/ Per Category	7	8	4	1	3	4	4	3	2	Per Student Group 35

	Sign	Commit.	Position	Exp Op	E to H	Corr to C	Cause to Eff	Conseq	Analogy	
F2	12	13	8	1	5	0	5	5	1	
GM3	0	4	0	0	5	0	0	0	0	
GR3	0	4	3	0	0	5	1	0	0	
S1	7	7	4	0	1	1	1	2	2	
Z3	1	0	1	0	1	1	10	0	0	
Total # of Arguments	20	28	16	1	12	7	17	7	3	NonSEPIA
										Average Number of Arguments
Average # of Arguments Per Group/ Per Category	4	6	3	0	2	1	3	1	1	Per Student Group 22

Table 3

Collapsed Categories



	Request for Info	Expert Opinion	Inference	Analogy
F1	32	2	20	3
F3	31	3	36	2
GM1	21	4	25	3
GM2	11	0	8	3
GR1	10	0	3	1
GR2	8	0	12	1
R2	23	0	19	2
S2	17	1	11	1
S3	20	1	6	1
Z1	14	1	11	0
Z2	13	0	3	0
Total # of Arguments	200	12	154	17
Average # of Arguments Per Group/ Per Category	**18**	**1**	**14**	**2**

SEPIA
Average Number of Arguments Per Student Group 35

	Request for Info	Expert Opinion	Inference	Analogy
F2	33	1	15	1
GM3	4	0	5	0
GR3	7	0	6	0
S1	18	0	5	2
Z3	2	0	12	0
Total # of Arguments	64	1	43	3
Average # of Arguments Per Group/ Per Category	**13**	**0**	**9**	**1**

NonSEPIA
Average Number of Arguments Per Student Group 22

Collapsed Categories

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

Figure 1

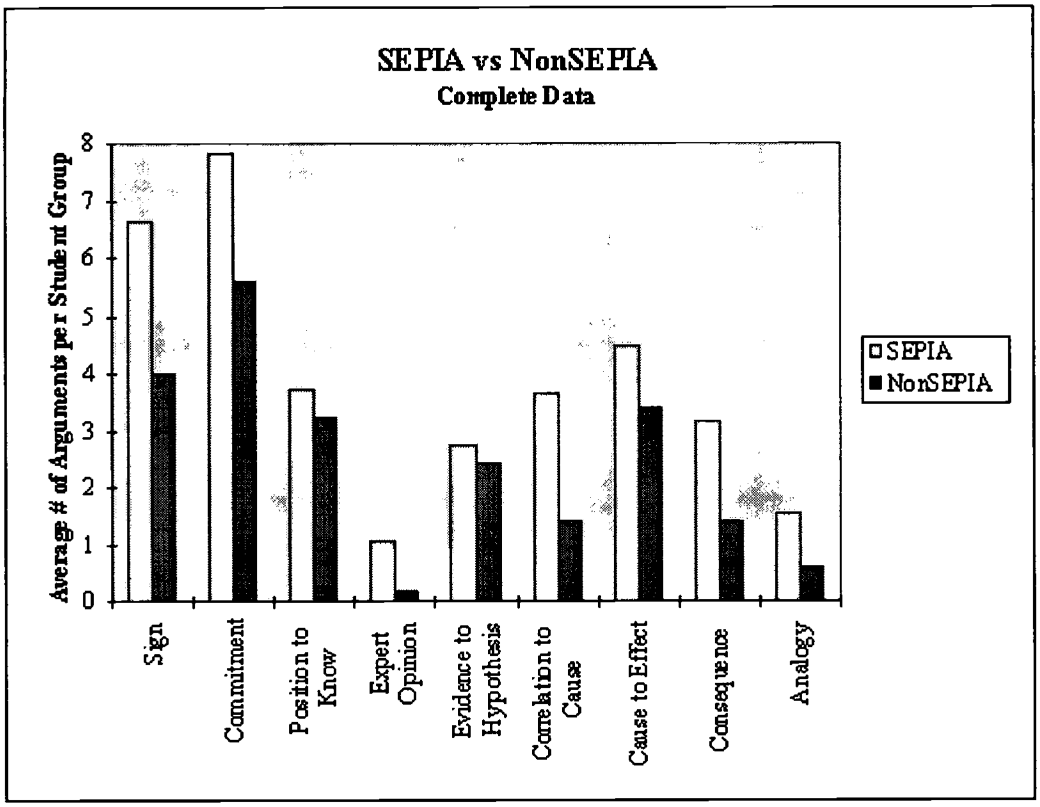


Figure 2

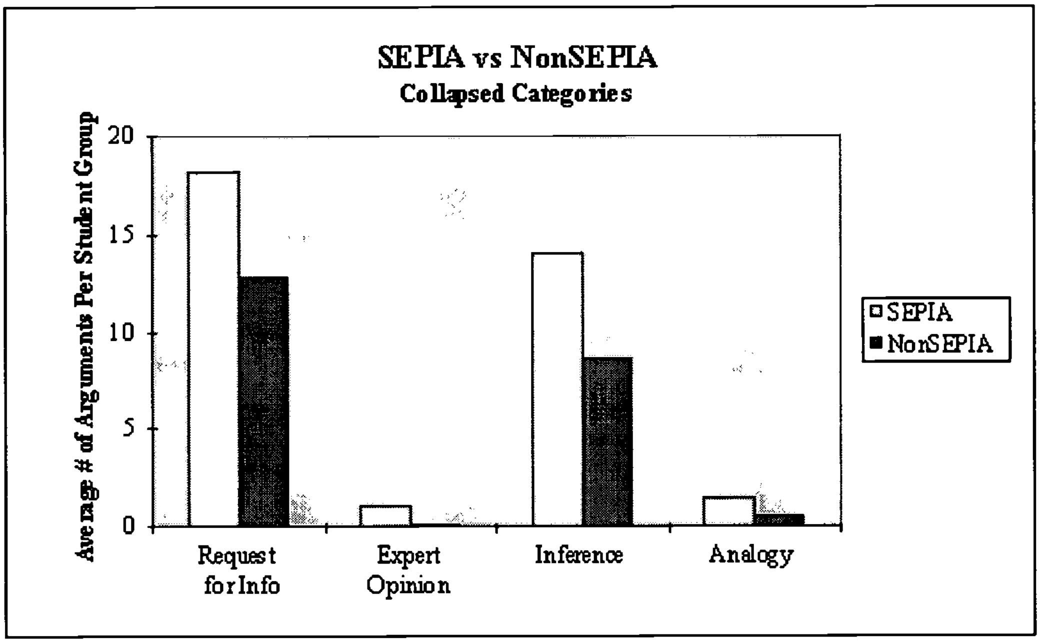
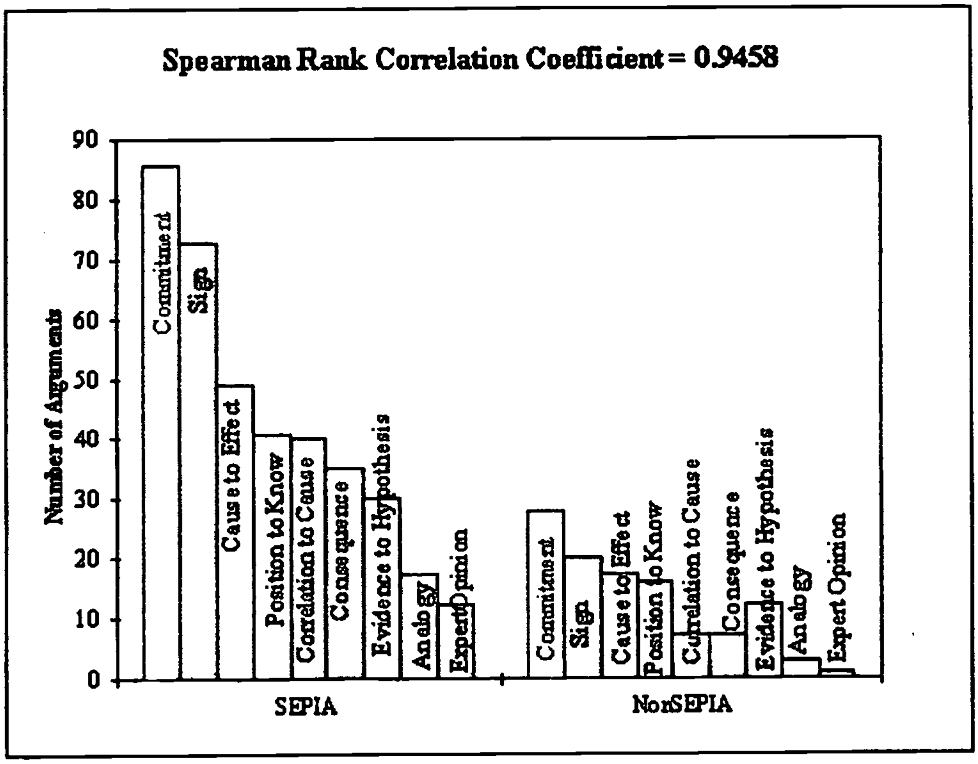


Figure 3

Rank of Argument Categories


Spearman Rank Correlation Coefficient = 0.9458
Number of Arguments
0
10
20
30
40
50
60
70
80
90
Commitment
Sign
Cause to Effect
Position to Know
Correlation to Cause
Consequence
Evidence to Hypothesis
Analogy
Expert Opinion
SEPIA
Commitment
Sign
Cause to Effect
Position to Know
Correlation to Cause
Consequence
Evidence to Hypothesis
Analogy
Expert Opinion
NonSEPIA

TO: Nigui Bectrum

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Signature:	Printed Name/Position/Title: Richard Duschl	
Organization/Address: King's College London, School of Education Waterloo Road London SE1 9NN ENGLAND	Telephone: 44-207-848-3044	FAX: 44-207-848-3182
	E-Mail Address: Richard.duschl@kcl.ac.uk	Date: 20 June 01

(over)