Teaching and Learning the Elements of Argumentation

by

Brian Untereiner
Bachelor of Science, University of Victoria, 1995
Bachelor of Education, Malaspina University-College, 1999

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Supervisory Committee

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Abstract

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In this study I investigated the interactions of 25 Grade 8 science students as they learned how to construct oral arguments using the Toulmin Argumentation Pattern framework. I collected the data during three recorded small group discussion sessions during a five week Earth Science unit between February and March of 2011. The first session recorded the students' discussions prior to receiving either argumentation instruction or the science concept instruction. The second session recorded their discussions after receiving an introduction to argumentation and a scaffold, but not concept instruction. During the three weeks preceding the third session, the students received additional argumentation instruction and completed one-third of the Earth Science unit. The results showed the students collectively made more arguments during each subsequent session. The students' individual arguments showed a correspondence between their purportedly most familiar topics and the most discussed topics. I also found that when students made counter arguments and/or invited or challenged group members to participate, their discussions contained comparatively more argument elements (claims, data and warrants) than discussions containing predominantly collaborative assertions. The key outcome of this study for developing students' use of the elements of argumentation during classroom discussions was to recognize and incorporate opportunities for the students to tap into their prior-knowledge. To engage students in this process, the results indicate the importance of creating time for discussions relevant to the curriculum and to the students.

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Chapter 1 – Introduction

Rationale for this study

The rationale for designing and carrying out this study was to contribute to the understanding of how people can be taught, and so learn, the skills involved in scientific argumentation. Specifically, I wanted to learn how to teach my students the skill of asserting, backing, explaining and questioning their ideas and those of others. The concepts students explore and discuss in science, regardless of the grade level, provide numerous opportunities for this skill development to occur. I consequently became very reflective of my instruction practices and was determined to better enable my students to communicate in a manner indicative of a scientifically literate citizen.

The subsequent approach to developing a teaching and assessment methodology for this study will take the following four steps:

1. Confirm the relevance of argumentation instruction by determining its place in the foundations of scientific literacy.
2. Gain familiarity with the variety of instructional and assessment approaches found in the literature that have been proven to encourage and recognize skill development.
3. Choose and adapt an argumentation framework to meet the learning needs of both the students and the complexities of the science curriculum.
4. Amalgamate the conclusions and recommendations of past studies to create this study's design features.

Through this research process, I expect to become more fully aware of the factors encouraging and inhibiting my students' argumentation skill development. In particular, I anticipate an improved understanding of: the role students' prior topic knowledge may play in their participation during discussions; the types of topics and discussion formats that best promote skill development; the best usage of frameworks and discussion scaffolds to guide skill development and communication practice.

Early foundations of scientific literacy in science education

Since the late 1970s, science education and cognition researchers have suggested a shift from the unidirectional processes of speaker to listener, text to reader, or memory to text in science instruction to include oral discourse in a sociocultural context (Yore, Bisanz & Hand, 2003). In recognition of this research, the 1990 UNESCO "World Conference on Education for All" argued that science education should promote scientifically and technologically literate citizens (see Millar, 2006). Heeding this call, the Council of Ministers of Education, Canada (CMEC) endorsed the Victoria Declaration in September 1993, leading to the "Pan-Canadian protocol for collaboration on school curriculum" in 1997. Concurrently, similar declarations were being made in the United States, the United Kingdom, Australia and New Zealand (Miller, 2006). The objectives for each of these high-level deliberations were to define and promote a standards-based definition of scientific literacy and to construct an educational framework to enable its implementation by curriculum developers and educators.

The collective vision of those Canadian Ministers of Education was that all Canadian students, regardless of gender or cultural background, have an opportunity to develop scientific literacy. The CMEC defined science literacy as an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving and decision-making abilities, and to maintain a sense of wonder about the world around them. To facilitate the adoption of their framework by curriculum developers and educators across Canada, the protocol presented four foundation statements that delineated the critical aspects of students' scientific literacy:

- Foundation 1 – Science, technology, society, and the environment (STSE). Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.
- Foundation 2 – Skills. Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.
- Foundation 3 – Knowledge. Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.
- Foundation 4 – Attitudes. Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and

technological knowledge to the mutual benefit of self, society, and the environment.

(Council of Ministers of Education, Canada, 1997)

In relation to these foundation statements, are learning outcomes set to guide curriculum developers and teachers in promoting scientific literacy. For Grade 8 students (the age group of focus in this study), CMEC provided the following learning outcomes specific to the inclusion of language arts skills in science curricula. It is expected that students will:

- Communicate questions, ideas, intentions, plans, and results, using oral language and other means
- Defend a given position on an issue or problem based on their findings
- State a prediction and a hypothesis based on background information or an observed pattern of events
- State a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea
- Receive, understand, and act on the ideas of others

Supporting these expected learning outcomes is the reality that when scientists carry out authentic science in research they are using elements of argumentation in an attempt to establish clear connections among claims, warrants and evidence (Kuhn, 1993; Yore and Treagust, 2006). Consequently, science teachers need to give their students an opportunity and ability to construct these same communicative elements if there is to be a revitalization of interest in science

and a creation of scientifically literate citizens (Amgen, 2012). Despite this, Newton, Driver and Osborne (1999) found that less than 5% of class time is devoted to discussion in science courses. Furthermore, the research on oral discourse in science learning remains scant and science instructional practices remain unchanged (Millar, 2006).

Oral discourse and scientific literacy

Teaching students the communicative skills of argumentation not only builds a foundation for a scientifically literate citizen, but also improves classroom learning. Lemke (1989), in his seminal work that preceded the UNESCO call for scientifically literate citizens, asserted that in order for students to take up the language of science, they need guided practice opportunities to make the text talk in their own voices by elaborating on it themselves, building on it in their own words, and making its words their own. According to Lemke, teachers who create these opportunities are enabling students to speak increasingly naturally in a language they were unable to before. Consequently, oral language discourse is critical for science literacy in the classroom. Furthermore, Kempa and Ayob (1995) found that 40–50% of the science ideas contained in students' written responses could be attributed to their oral interactions during small-group discussions. Around the same time, Blank (2000) noted that by providing students with opportunities to discuss their results and knowledge claims there was a significantly higher retention shown in test scores. Blank also detected a difference in the purposefulness of oral discourse, with the discussion group being more engaged and thoughtful. Adding support to Blank's findings were the results of Chi's 2009 meta-

analysis of 18 studies. Chi found by comparing the learning gains of three categories of grouped learning activities (interactive, constructive and active), interactive activities that require collaborative discourse and argumentation showed the most effective learning gains (See Osborne, 2010). These findings support the argument that argumentation skill instruction and science learning are facilitated through discussion opportunities in the classroom.

The skill of argumentation – A critical requirement for scientific literacy

In recent years, an increasing number of studies have focused on understanding how to teach students the communication skills necessary for scientific literacy. In science, where ideas are being developed, tested, analyzed and debated, learning the synergistic elements of argumentation is essential. Consequently, guiding the research has been the creation, promotion and application of a variety of argumentation frameworks. The common objective behind each of these frameworks is to offer a reliable and repeatable teaching framework and assessment tool of quality argumentation. Two types of frameworks are evident in the literature reviewed for this study: those that are domain-general (applicable to analyses of argument quality in disciplines and topics both inside and outside of science), and those that are domain-specific (specific to the language and contexts used in science). Within both "groupings", researchers may judge – with exceptions – the quality of the students' arguments based on the structure or complexity of the argument (the number and cohesiveness of elements contained in the argument), and the content of an argument (the accuracy or adequacy of the various components in the argument).

Frameworks for teaching argumentation

The framework developed by Toulmin (1958) remains the most common of the argumentation frameworks. It enables researchers to inform argument instruction and examine argument quality in a variety of subject areas aside from science. It originally comprised a pattern of six cohesive elements, including: claims and counterclaims, data, warrants, backing, qualifiers and rebuttals.

Claims and counterclaims are the two most frequently observed argument features in a discussion. A claim represents the thesis a speaker is promoting, while a counterclaim represents a speaker's attempt to negate or promote disagreement with an opponent's thesis or position. Data is the hard facts and the reasoning added to an argument to support the claim. A warrant is an explanation of the link between the data and the claim. Backing gives additional support to the warrant by answering different questions. Qualifiers reveal the limitations of the data and the claims. They include words such as "most", "usually", "always" or "sometimes". A rebuttal is a countering argument in itself and therefore may include some or all of the elements of an argument.

An argument containing some or all of the elements is considered collectively to be an example of a Toulmin Argument Pattern (TAP). The strength of an argument is based on the presence or absence of combinations of these structural components (Sampson & Clark, 2008). According to Reznitskaya et al. (2007), for example, a strong argument consists of a claim with supporting evidence, or a challenge to a claim (rebuttal) with its own application of evidence. Backing for the

use of a framework using fewer elements stems from the recognition that students make infrequent usage of warrants and backings (Sampson & Clark, 2008).

Yore and Treagust (2006) lauded the use of Toulmin's Argument Pattern (TAP) by Osborne, Erduran and Simon (2004) to the extent that it encourages teachers to incorporate the elements of argumentation into their lessons. However, they questioned the authors' connection between the students' inclusion of the elements and a sense of scientific literacy. TAP, according to Yore and Treagust (2006), is a noteworthy first step in documenting argumentation, but it needs to move beyond detecting and counting elements of argumentation and more closely identifying the students' science understanding.

Osborne, Erduran, and Simon (2004) defended their decision to not focus on the content of the students' arguments. They placed greater value on the development of a workable framework "to examine the process of argumentation, as this is the foundation of rational thought, and to determine whether that process can be facilitated and its quality assessed" (Osborne, Erduran, & Simon, 2004: 1015). The CMEC (1997) foundation statement referring to "Skill" (communicating scientific ideas and working collaboratively) supports this point as the students are demonstrating scientific literacy by showing an ability to acquire and apply the communicative skill of argumentation using TAP regardless of the content of the argument.

Nevertheless, the observation that the application of the TAP framework to an oral argument may give a false sense of the student's science understanding remains valid. That is, even if a student's evidence is incorrect, or the linking

warrant they are applying is inaccurate from a scientific perspective, the argument will appear strong structurally. Consequently, Toulmin's Argument Pattern may need to be modified to serve its goal in guiding teachers and students towards achieving scientific literacy.

Schwarz, Neuman, Gil and Ilya (2003) also developed an argumentation framework to be used in the context of science education. It shares some similarities with the Toulmin Argument Pattern in that it assesses the use of evidence in backing a claim. In Schwarz and colleague's (2003) framework, however, the highest quality evidence is drawn from background knowledge, personal experiences and the claims of others. That is, evidence deemed appropriate does not require an empirical base.

Additional frameworks noted in the literature for assessing scientific arguments include those developed by Lawson (2003), which assesses deductive validity, and by Sandoval (2003; Sandoval and Millwood, 2005), which assesses conceptual and epistemological quality. Consequently, since the challenge for this study was to analyze the structure of the students' arguments, I selected the Toulmin Argument Pattern.

Project design features enabling students' argumentation skill uptake

As acknowledged by every author discussed here, the traditional teacher-centered approach to science classroom instruction remains prevalent today. Consequently, it is not surprising all but two of the studies shown in Table 4 below offered the students a questioning scaffold to help build familiarity and confidence in using the new language skills contained in argumentation.

Table 1
The Use of a Scaffold

Author	**Date**	**Scaffold**	**Comments**
Gillies and Khan	(2009)	Yes	The condition group with the scaffold (questioning framework) demonstrated greater use of oral argumentation skills; however, skills were not transferred to written work with the scaffold removed.
Berland and Reiser	(2009)	Yes	Scaffolds were provided in the Investigating and Questioning our World Through Science and Technology (IQWST) claim/evidence/reasoning framework
Cross, Taasoobshirazi, Hendricks, and Hickey	(2008)	No	Scaffold not formerly provided, but a model in the form of a cartoon video modeling argumentation, engagement and turn-taking was presented at the outset.
Martin and Hand	(2007)	Yes	Both the teacher and the students were provided with scaffolding to guide their skill development.
Simon, Erduran and Osborne	(2004) (2006)	Yes	TAP Framework and scaffold offered to the participating teachers, but lesson development and delivery method remained the prerogative of each teacher.
Cho and Jonassen	(2002)	Yes	Scaffold was removed at the end of the study to determine if the observed argumentation skills would be transferred. It wasn't transferred.
Duschl, and Duschl, Ellenbogen and Erduran	(1999) (2001)	No	Not explicitly stated. This study relied solely on the SEPIA style of classroom learning to promote the development and use of argumentation skills.

Aside from the presence of a scaffold, the salient project design features shown in the above studies to support the effective instruction and use of argumentation in the science classroom included:

- In addition to training prior to the commencement of the study, expert support available as needed or present at regular intervals.
- Science units and lessons crafted incorporating the prescribed learning outcomes, authentic activities and open-ended discussion topics that promoted the practice of argumentation.
- Many opportunities for argumentation to be modeled, practiced and recorded, not only for data collection purposes, but also for skill

development.

- Scaffolds and frameworks used initially, but later removed to ascertain the students' degree of argumentation skill development.

Conversely, the salient project design features found in those studies that contributed to the low to no positive effect size (especially when the scaffold was removed) were:

- Teacher training limited to a single professional development workshop offered at the outset of the study with no follow-up training.
- Teacher commitment to learning and modeling the skill of argumentation was not a prerequisite for their involvement.
- Frequency of data gathering limited to one or two events, often at the beginning and end of the study.
- Few to no opportunities for whole class discussions.
- Unit topics disconnected from the prescribed curriculum (discussions not authentic for the students).
- Sufficient practice opportunities listening to and using the skills of argumentation with, and later without, a scaffold were lacking.

Identifying potential design features for designing and implementing a study to encourage and track argumentation skill development in a middle school science classroom was one of the motivators for this review. By noting the successful and not-so successful features of a variety of studies, I gained a greater understanding of the challenges the teaching and learning process entails.

First of all, the unanimous voice expressed in the above referenced papers is that the traditional science classroom-learning format does not develop the communicative skill necessary for strong scientific literacy in students. To address this, I concur with all of the above papers whose study environment was a classroom that offered a cooperative learning environment valuing the open sharing, evaluating and critiquing of ideas using as many sources and modes of information as available. Without this environment, student comfort in openly expressing a position is weakened, and the application of the skills of argumentation without a scaffold is, as demonstrated, unlikely.

Successful teaching of argumentation skills allows students to explore, share, evaluate and question ideas while still following the curriculum. The activities presented in the classroom, while meeting the prescribed learning outcomes, must challenge students to consider alternative points of view and assess a variety of information sources. In order to do this, the successful studies described above made sure the topics encouraged open-ended discussions—topics must lack obvious solutions or encourage multiple points of view—and were socially relevant to encourage critical thinking and engagement.

Scaffolding was widely used in the research. The importance of providing the students with a scaffold to use as a reference during discussions is clear; the traditional teacher-centered approach makes the work of making claims, warrants and rebuttals a new challenge. So support is necessary. That said, recognition of the failure of a majority of the studies to observe student usage of the elements of argumentation with the scaffold removed is necessary. As demonstrated by Martin

and Hand (2007), however, with sufficient training (of the student and teacher), integration of the argumentation skills into regular classroom communication is possible.

Chapter 2 – Research process

In this chapter, the foundational elements of this project's design are presented, and the rationale for their inclusion is offered. This information is provided in the following five sections:

1. The research questions that directed the study
2. The rationale for the argumentation framework chosen to guide instruction and assessment
3. The students that participated in the study
4. The classroom activities that facilitated argumentation skill development
5. The approach to data collection and its analysis

Research questions

Three research questions framed this study. They are:

1. Will the students make comparatively more arguments while discussing topics purportedly familiar to them?
2. Can argumentation instruction and the provision of a scaffold facilitate greater usage of TAP across all of the discussion topics?
3. Will the students continue to demonstrate the skills of argumentation without the use of a scaffold after receiving Earth Science curriculum instruction?

My rationale behind the first question was to determine whether a students' desire to participate in discussions was dependent on their topic knowledge. If the results demonstrate this to be true, I would argue that in order to teach the

communicative skills of the scientifically literate citizen, concept instruction and/or topic knowledge needs to precede argumentation instruction.

The second research question serves to assess the efficacy of my instructional activities. If the transcripts reveal an increased usage of Toulmin's elements throughout the second session, regardless of the topics discussed, I would argue the students can be taught to incorporate the elements of argumentation into their discussions regardless of their purported topic knowledge.

The third question sought to determine whether, or not, the students became equipped with the communicative skill of a scientifically literate citizen through the instructional activities.

Rationale for the Toulmin Argument Pattern (TAP)

When drafting the idea for this project in the fall of 2010, the Toulmin Argument Pattern was a popular framework in the literature for teaching and assessing argumentation. Its elements were easily defined, and its domain-general structure made it adaptable to a wide variety of discussion topics. Consequently, when I took into consideration the wide variety of topics I cover during my instruction of the Grade 8 Earth Science Unit – and the anticipated length of the students' recorded transcripts – this adaptability cemented my decision to incorporate the structure of TAP into my instruction and into my coding rubric. However, the difficulty in assessing the content quality of a student's argument using TAP remained a concern.

To address the critique of TAP for its inability to assess the content of the students' contributions, I, through an iterative process of consultation and

collaboration with members of my thesis committee, developed a rubric that defined levels of sophistication to each of the elements being coded. By creating this rubric, TAP, with its ease of use and multi-context adaptability, would have the potential for being a defensible arbiter of topic understanding, scientific literacy and argumentation.

Participants in the study

The setting for this study was an independent school on southern Vancouver Island that teaches students from Kindergarten to grade 9. 25 grade 8 students consisting of 11 girls and 14 boys made up the study's entirely voluntary group. In following the ethical standards outlined by the Human Ethics Review Board (HREB), the analysis of the students' transcripts did not start until the end of the school year (June 2011).

Classroom activities

Lesson 1: February 21, introducing argumentation and recording session #1. The opening lesson in the research project had three main objectives. The first was to elicit the students' understanding of the word "argumentation". The second was to discern their perceived topic knowledge of the concepts to be learned in the upcoming Earth Science Unit: Water. The third objective was to record the first of three small group discussions. It is important to note that I provided no formal instruction on either the features of argumentation or earth science during the 95 minutes of instructional time. I held off teaching the students about making claims, including data and providing warrants until the second and subsequent lessons. This provided the opportunity for me to ascertain their pre-instruction

argumentation abilities. The following is a summary and justification of the activities and tasks carried out in the classroom and computer lab.

Step 1: Discussion and classroom practice. After a brief class discussion on the students' interpretation of the word "argumentation", I picked two questions for the class to "argue" as a whole. The first question: "Which game system is better, X-Box 360 or Nintendo DS?" provided the students with an opportunity to discuss a topic I knew was of interest, or at least familiar, to them. The second question also took into consideration a hobby shared by many students in the classroom: "Which can travel downhill faster, a mountain bike or a motocross bike?". These short activities shared two purposes. First, they provided time for guided whole class open-ended discussions and argumentation practice. This was a positive design feature observed during the literature review – not just for data collection purposes, but also for skill development. Second, they encouraged the students to communicate their ideas and concept knowledge; a part of the second foundation of scientific literacy ("Skills") put forward by the CMEC.

The students most vocal during this classroom "practice" discussion, despite receiving no training, were modeling effective argumentation: positions were taken (claims and counterclaims were made) and background knowledge and findings from outside sources were provided as support (evidence was used). I asked the students to identify the features of the successful arguments they just heard. They responded by saying that the students who were best able to prove they were right, or change someone's mind were the ones using the most facts.

Step 2: Introducing the unit topics – Student self-ranking of topic knowledge. Before I lead the students to the computer laboratory to record their discussions, I presented them with an overview of the topics to be covered in the upcoming Earth Science Unit: Water. These nine topics – all linked to the British Columbia Ministry of Education Prescribed Learning Outcomes for Science 8 (2006) – are listed below:

- Sources of fresh water
- Properties of salt water and fresh water
- Effect of ocean currents and winds on regional climates
- Effect of water and ice on surface features
- Weathering and erosion
- Evidence and affects of glaciations
- Impact of waves, tides, and water flow on surface features
- Productivity and species distribution in aquatic environments
- Diversity of aquatic life forms

With this list, I asked the students to reflect on and rank their own perceived knowledge of each topic. I collected these responses for later use in analyzing and comparing their self-declared prior knowledge with their respective argument performances during the recordings.

Step 3: Recording session #1. The students then moved to the school's computer laboratory, and I asked them to group themselves into twos or threes. I demonstrated how to open the Apple voice recording software "GarageBand" and start a new recording project. I then distributed one envelope to each group. The

envelopes contained the same nine topics the students considered earlier in the lesson (refer to Step 2 above). To promote argumentation practice, and determine their actual level of topic knowledge, however, each topic (printed on separate pieces of paper) contained up to eight open-ended discussion-prompting questions for them to work through in their small groups. An example of a question in the "Sources of Fresh Water" section asked:

> Would you approve of allowing companies to take water from a local river, bottle it, and then sell it to people living in other areas?

My objective for the questions was to prompt the students to share their ideas on the topic and either work collaboratively toward a consensus or convince the other members to accept the "best" idea. These questions met the requirements defined in CMEC's four foundations. That is, the topics linked science, technology, society and the environment (STSE); the students used and strengthened their skill of communicating scientific ideas and worked to make informed decisions; the students applied their shared understandings of the earth science concepts to interpret, integrate and extend their own knowledge in a way that is mutually beneficial to self, society and the environment.

Due to the length of time spent in the classroom, this first recording session lasted an average of just over eight minutes. Most of the groups discussed approximately one half of the topics. My plan was for the students to discuss the remaining topics during the second recording section.

Lesson 2: February 24, teaching argumentation (continued) and recording session #2. The second day in the research project took place on the

next scheduled Science 8 class. I set four objectives for this 95-minute block of time prior to finishing the recorded arguments. First, I gave the students approximately 20 minutes to collectively self-reflect on their discussions during the previous lesson. Second, we spent approximately 15 minutes discussing the types of professionals that use argumentation as part of their daily acumen. Third, I took another 15 minutes to present and define, with the students' support, four elements of a structured argument using the Toulmin Argument Pattern (TAP). Fourth, I allocated approximately 25 minutes to present to the students excerpts taken from their own discussion transcripts. I used the remaining 20 minutes of the lesson in the computer lab to carry out the second recording session.

For this lesson, I chose not to start my instruction of the Earth Science unit. I wanted to determine whether prior knowledge remained an influential factor controlling the usage of claim, data and warrants even after the students received argument instruction. Starting the unit prior to finishing the discussions would have complicated this discernment.

Step 1: Reflecting on lesson 1. I asked the students to share what they predicted was going to be difficult or challenging before starting to work through the discussion topics the previous day. The top two answers – as voted by the class – were:

- I was worried that if I said something wrong, I would sound stupid.
- I thought I would have nothing to say.

These answers informed me of the necessity of positively reinforcing the students' efforts from Day 1, to provide them with more practice, and to teach them how to

formulate an argument. In doing so, I strove to build their confidence in taking their ideas and developing a case for them.

I then asked the students to recall what parts of the session were fun and interesting. Among the student-answers written on the whiteboard, the following received the most votes:

- Having more control over what I can talk about.
- Not having to write down what I want to say.

Despite generating a variety of answers to this question, the students quickly decided on these two after viewing all of the groups' responses posted on the whiteboard. As these popular answers reveal, the students preferred having a say in what they could talk about. The students justified the appeal of not having to write their arguments down by explaining they would not have been able to produce and share as many ideas if they were expected to do so.

Step 2: The role of argumentation in society and science. I asked the students to consider the field of science as the type of profession where knowing how to argue well is a very important part of the job. One student responded that a scientist just works in a lab performing experiments and so has little reason to argue. I attempted to change this notion by asking the students to consider the scientific process they were taught to demonstrate in their lab reports with the following scenario:

A scientist discovered that mold spores could be used to kill harmful bacterial infections. Unfortunately, people paid little attention to him when he shared his findings.

I asked my students rhetorically, “How should he make himself heard? How can he convince people to accept and fund his research? By telling people that his discovery is a valid and worthy investment”, I concluded. My goal was for the students to realize that if a scientist is unable to present their findings in a convincing manner, no one will accept, support or buy into their work. With this goal assumed, I explained that is why scientists stand to benefit by using the same techniques of argumentation as lawyers and politicians.

Step 3: Presenting the structured argument – The Toulmin argument pattern (TAP). At this point in the lesson, I distributed copies of the scaffold (Figure 1, below) – adapted from Hand (2010) – to the students. The scaffold shows how elements of an argument may be used to support or refute an initial claim. After spending ten minutes talking about the definitions for each element, I presented on the whiteboard three excerpts of small group discussions taken from the transcripts during the first recording session (Only the first excerpt the students reviewed is shown below). From the excerpts, I encouraged everyone to identify the elements of argumentation they believe were used by referring to the above handout and the definitions of the elements.

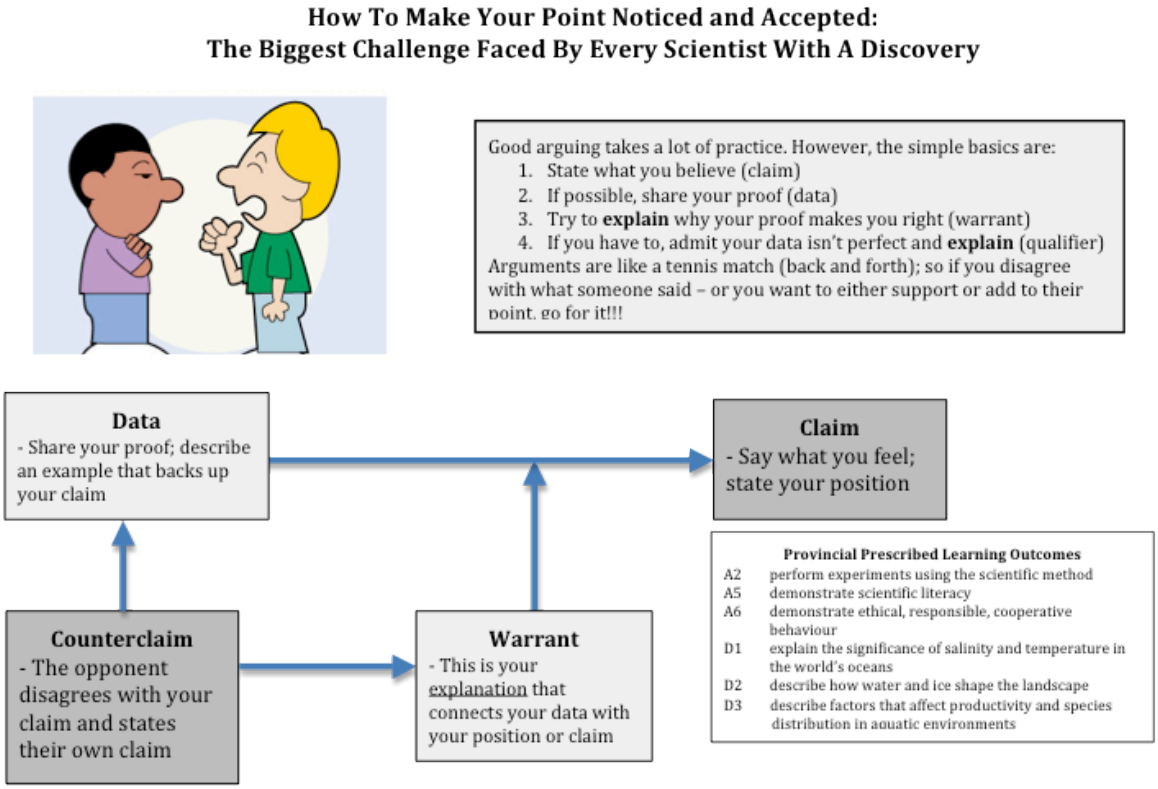

Figure 1 Toulmin argument pattern guide

Table 2
Excerpt from session 1

Day 1 Line 290	*Question: "What impacts do you think we are having on the food web and diversity in our lakes, rivers and oceans?"*
Jenny Line 291	I think it's a bad thing, what we are doing, because oil spills and people have been dropping garbage into the waters, and it affects the animals in the lakes, rivers and the oceans. And it's not good.
Fraser Line 292	I think we have created some problems, but we've also done many things to help it. Like nowadays; there used to be a small number of salmon, but slowly they have been increasing due to the fact that people have been helping. We have been trying to; we have taken salmon and we've got them – we've put them in the fisheries – we've got them reproduced and increased the amount of salmon. People have helped in the end.
Jenny Line 293	Yes, but then again, still people need to change their acts and not pollute as much and recycle more so it doesn't go straight into the oceans.
Fraser Line 294	I do agree about the garbage we have in the oceans and things like that. Yes, that needs help. Yes, but the big oil spill that just happened awhile back was an accident. And you can't always prevent accidents.

The students reviewed the excerpt and provided the following feedback:

- They didn't just say they agreed or disagreed, but they both included an explanation why they felt the way they did.
- They both gave examples.
- They both listened to the other person's points.

The students' identification of Toulmin's elements of argumentation in the excerpt resulted in the following comments:

- "Jenny" made a claim that we are doing bad things. She also talked about how we are dropping garbage into waters to show she was right. This is data.
- "Fraser" started off by first agreeing and then disagreeing with Jenny's claim. He made a counterclaim.
- Fraser then goes on to talk about salmon, and that is data, because it backed up his claim.

As the students discussed the excerpts they seemed to be increasingly able to recognize examples of claim, counterclaim and data. They did not initially identify any instances of warrant. I intervened for ten minutes to provide instruction about warrants by asking the students to consider the influence of Jenny's explanation on the effects of "dropping garbage into the waters" (Line 291); it added relevance to her data and so strengthened her claim. Upon hearing the excerpt, one student was able to identify examples of counterclaim, data, and warrant in Fraser's first speaking turn (Line 292). A summary of this student's analysis, written onto the whiteboard with my support, was as follows:

- Fraser finished his turn by claiming that since we are doing these things for salmon. We are helping. He followed this up with data on salmon to support his claim. Fraser's last sentence in his first turn repeated that the growth in salmon is thanks to the efforts of humans. This means he is explaining how the salmon example is proving his first point – his claim. This makes it a warrant.

While no tests were conducted to ascertain a possible improvement in the students' ability to recognize the elements, creating opportunities for them to observe and talk about argumentation was a good instructional practice – as suggested in the literature.

***Step 4: Recording session #2*.** The students spent the remaining 20 minutes of class time in the computer lab completing their small group discussions using the earth science discussion handouts presented prior to the first recording session. Notably for this session, the students had the scaffold (Figure 1) to assist them in incorporating Toulmin's elements of argumentation into their discussions. For later analysis, I was curious to determine whether the students would be able to demonstrate an increased usage of the elements of argumentation over the first recording session. Supporting such an improvement was the argument instruction and the scaffold. However, considering the possibility the students opted to discuss their most familiar topics during the first recording session, I was uncertain.

Lessons 3-8: Working towards recording session #3. The next stage of this study (February 28 – March 17) contained six lessons (two lessons per week –

each approximately 95 minutes long) leading up to the third and final recording session. During that time, one-third of the unit's content was covered.

Lesson 3: February 28, assigning an independent research project.

While the students' enthusiasm and oral participation was very good during the first two lessons, I did not provide them with any time to draft arguments or research and gather supporting evidence – they could only rely their background knowledge. So, I felt a key to building their skill at argumentation was to have them immersed in researching and constructing a written argument on a topic of their choosing connected to the Water Unit. Consequently, at the start of the third lesson I asked the students to take another look at the handout I presented to them on February 17th, showing the nine topics to be learned in the unit (See "Lesson 1: Step 4" above). I gave the students ten minutes to consider which topic they would like to research and learn more about. I then handed out the Independent Research Project criteria sheet. The format of the project was framed around a scientific argument. An important pedagogical rationale behind the assignment, aside from appealing to the students' fondness of research reports, was to explicitly train them to construct and express their ideas with greater evidence and explanations. My research aim for this activity, though, was to prepare the students to display relatively higher levels of argument skill going into the third recording session. The criteria sheet included the following expected framework:

> Part 1: State, in a detailed paragraph, the reason why you chose your topic, and include in that section your claim.

Part 2: Collect and present information, images, graphs, etc (backing data) from various websites to support your claim.

Part 3: Discuss in a detailed paragraph (minimum) how your data section (Part 2) supports your claim (warrant).

Part 4: Discuss, with collected data, images, graphs, etc, the position of your opponents (the people, government, or companies that disagree with your claim).

Part 5: In a detailed paragraph, discuss how the opposing viewpoints do not affect your position.

Part 6: Conclude in a summary paragraph a discussion of what you learned.

Part 7: Present your report to the class and respond to questions raised by your peers.

My rationale behind providing the above framework was to direct the students towards including the elements outlined in Toulmin's Argument Pattern (See Figure 1) and so gain greater familiarity with each element as they completed the assignment. I gave the students the remainder of the period (approximately seventy minutes) as well as the latter half of the next scheduled science class to use the Internet to research their topics. Examples of the students' research topics (claims) linked to one or more of the nine Water unit topics included:

- Clean drinking water is becoming scarce
- The amount of water and toxins that are used by golf courses is detrimental to humans and the environment
- Caves are being destroyed by humans and need to be preserved

- If commercial fishing continues, sea life will be in great danger
- The zebra mussel is rapidly affecting the diversity of life in the Great Lakes

Lesson 4: March 3, teaching the earth science concepts and facilitating research project (continued). As I mentioned earlier in this section, I delayed my formal instruction related to the Water Unit until after the first two recording sessions. With this accomplished, and the students well into their research projects, I could start the Science 8 instructional activities for the Water Unit.

In the first part of this block (approximately 35 minutes), I conducted a science lesson in the classroom. As I do for most in-class lessons, I gave the students a Smartboard presentation based on the curriculum provided in the text: *BC Science 8* (2006). My focus for this lesson was on the first section of the chapter: "The Distribution of Water".

My usual lesson delivery with the Smartboard involves providing the students with a cloze version of notes (students on Individual Education Plans receive an adapted version, depending on their learning needs), and as I work through the pages on the interactive whiteboard, the students share their own experiences and understandings of the concepts. Upon completion of this particular lesson, I assigned the section questions from the textbook and provided the students with approximately 15 minutes to work on them in class. For the remaining 45 minutes of the lesson, the students returned to the computer lab for the last time to revise and edit their research projects.

Lesson 5: March 7, practicing argumentation and teaching earth science concepts (continued). In the fifth lesson, after going over the text questions

assigned in the previous class, I introduced the new section in *BC Science 8* (10.2 – "Salinity") by giving the students the opportunity to work in groups of two to four to consider the following three questions displayed on the whiteboard:

1. Why is ocean water near the equator saltier than ocean water at Pacific Rim National Park?
2. Why is ocean water very salty at the North and South Poles?
3. Why is ocean water saltier in the middle of the ocean than near continents?

My challenge was for the students to argue a position by demonstrating their learned argumentation skills. Prior to setting them to this task, I asked for a volunteer to explain – by recalling the argument scaffold from Lesson 2 and the independent research project's criteria sheet – how a solid argument needs to be organized. One student came to the front and, with my support, listed the steps:

1. State your position by making a claim
2. Add data to support your claim
3. Explain how the data makes your claim true
4. After your opponent's turn, question either their claim or their data

After applauding the student's answer, I wrote next to each of the above statements an example to guide the students in crafting their arguments. I pasted the following textboxes onto the whiteboard display:

1. You should always stop to turn off dripping taps. (Claim)
2. If a tap drips twice every second, in 24 hours, it will have dripped 172,800 times, equaling 43 litres of clean, drinkable water. That's 15695 litres in a year. (Data)

3. Taking a moment to turn off the tap saves a lot of water. (Warrant)
4. Even if you weren't the person to leave the tap on, it is everyone's water that is being wasted. (Counterclaim)

With the simplified argument structure and example on the board, I challenged the students to spend ten minutes constructing their arguments for the three questions (listed above). When the class was ready, I assigned each group a number and then drew numbers from an envelope to determine which groups would argue against each other. If a group simply agreed with their opponent's statement, I encouraged them to add an additional supporting example. This activity took approximately 40 minutes. With the remaining 40 minutes in the lesson, I introduced salinity. As with the lesson for *BC Science 8* Section 10.1, I used the Smartboard for Section 10.2 and the students collaboratively completed a cloze version of the notes with my support.

Lessons 6 and 7: March 10 and March 14, teaching earth science concepts (continued). My instruction during the next two lessons did not involve argumentation. The sections I taught in the same manner as I described above were: "Sources of Fresh Water" (BC Science 8: Section 10.3) and "Weathering, Erosion and Deposition" (BC Science 8: Section 10.4).

Lesson 8: March 17, recording session #3. With the instructional and learning activities for the chapter completed, the students were set to complete the third and final small group recorded discussion. To focus the discussions, I selected a learning activity: "Tracking Run-Off" from *BC Science 8* (2006: 378) as the basis for the final argument. This activity challenged the students to:

- argue in support of or against a variety of community development proposals,
- consider the consequences related to the run-off on different areas depicted on a map provided, and to
- offer possible solutions.

I selected this activity because it presented an issue that is receiving much attention in a majority of the students' communities. It also prompted them to incorporate the earth science concepts they had learned to-date to build solid arguments using – hopefully – Toulmin's Argument Pattern (TAP) without the use of a scaffold.

The third recording session took the small groups, on average, seven minutes to complete. Upon completion of the recordings, the students returned to the class to review for the chapter test, set for the following lesson, by participating in a Jeopardy style review activity.

Concluding remarks. I selected the activities described above for the eight lessons to facilitate argumentation skill development (specifically, the use of the Toulmin Argument Pattern). Their inspiration came from the foundational understanding, skills, knowledge and attitudes of the scientifically literate citizen as defined by the UNESCO "World Conference on Education for All" (1990), the Council of Ministers of Education, Canada (1995), and British Columbia's Prescribed Learning Outcomes for grade 8 Science (2006). The success and shortcomings of the studies analyzed in this study's literature review further influenced my choices of how to create opportunities for the students to learn and practice argumentation via authentic and open-ended discussion topics. I also came to realize the importance of

recording the students' discussions over a series of sessions to track their growth upon receiving specific interventions. Finally, I learned the necessity of providing the students with an appropriate scaffold to guide their usage of the potentially unfamiliar language and structure of argumentation.

A determination of the success of my choices for the instructional activities is explored in the Results and Analysis chapters (later in this paper). Included in that examination is the possible influence of the variables: prior knowledge, topic choice and group dynamics.

Data collection and its analysis

In order to maximize the students' opportunities to participate in discussion activities, they worked in groups of two to four. Each group was assigned to a computer. The students' small-group discussions were recorded using Apple's Garageband software which was loaded onto the computers. A microphone in the computer recorded their discussions. The total length of the students' discussions during the three recording sessions (February 21, 24, and March 17 of 2011) was 193 minutes. The recordings were transcribed into an Excel document and later coded the material using the rubric designed specifically for this project. Excel formulae elucidated the students' usage frequencies of Toulmin's elements of argumentation during the three recording sessions. The resulting data enabled the tracking of the argumentation feature development during each recording session and ultimately suggest answers to my research questions.

Chapter 3 – Constructing a rubric

The next part of this thesis discusses the steps taken to construct and test a rubric that enables the objective coding of students' transcripts. With this process detailed, the analysis of the data will work to answer the questions asked in the above section.

Rationale behind coding rubric

The construction of the argumentation rubric was an iterative process. The coded transcripts that I am using for my analysis underwent three complete revisions and numerous refinements. I based each change on the suggestions offered by members of my thesis Supervisory Committee, and on my increasing familiarity of the range in sophistication of my students' arguments. The path I took to complete the rubric is outlined below.

First of all, my objective for the rubric was to facilitate a reliable and rigorous coding of my students' oral scientific arguments. The initial coding used four of Toulmin Argument Pattern's (TAP) elements divided into four levels. The elements were: Claim, Counterclaim, Data, and Warrant (Toulmin, 1958). I coded the transcripts (totalling approximately 193 minutes) using this scheme, and in August 2011, brought them and the rubric to two members of the thesis Supervisory Committee for verification and refinement. This process was repeated during our next meeting in August and again in December 2011, respectively. The final determination of how each element is defined and the level of sophistication the various arguments demonstrated in the transcripts is outlined below.

Claims

As noted in Chapter 2, a claim represents the thesis a speaker is promoting, while a counterclaim represents a speaker's attempt to negate or promote disagreement with an opponent's thesis or position. The consensus reached with two members of my thesis Supervisory Committee was that in the context of the group discussion in this research there was insufficient justification to distinguish these two elements. We also agreed that grouping claims and counterclaims into one element "claim" would not eliminate essential data for identifying the occurrence of these features. Recognizing this, I will use the word "claim" hereon in to refer to both claims and counterclaims.

In a consultative and collaborative process with the Supervisory Committee, four levels of claim were distinguished based on an examination of selected excerpts from the recording of student discussions. The four levels were then further subdivided into two to four sublevels by assigning a letter to facilitate the tracking and grouping of similarly coded assertions using formulae in Excel. A Level 1a claim, for example, is an assertion that did not relate to the topic being discussed. The respective Level 1b, c, and d claims were a simple contradiction or agreement, an exact restatement, or rephrasing of a previously asserted claim. The common feature is the absence of a pertinent or new idea being introduced into the discussion.

Level 2 claims and counterclaims can be differentiated from the above claims because the speaker is demonstrating an ability to elaborate on their own, or an opponent's previously introduced position (C2a), versus simply contradicting,

restating or rephrasing. Higher quality claims still classed within Level 2 were those which showed the students introducing their own opinion without including the spatial or temporal scope of their claim (C2b), or with an expressed awareness of scope (C2c). Consider the following claims demonstrating the presence and then absence of scope:

1. Lucy: "There are lots of developments in the Cowichan Valley that are not even doing anything." (Day 2, Line 25)
2. Annie: "So, as water flows down a hill it creates erosion like mudslides." (Day 1, Line 36)

In the first excerpt, the student demonstrated sufficient knowledge of the topic to specify a location where the situation is occurring. Other details that can demonstrate an awareness of scope include the temporal and spatial extents of the occurrence or event being discussed. The second excerpt does not include any description of a location, a time or an extent where the claim may occur.

In making a Level 3 claim, the speaker is demonstrating personal experience with the topic being discussed. These claims contain appropriate spatial or temporal limits which represent a deeper understanding of the scope and limits of a claim. The speaker is demonstrating a greater degree of reflection and mitigation of experience and understanding compared to students not including personal experience or the scope of the topic. Initially, differentiating the quality of the claim at this level was to be made by checking for the presence of scope within the claim feature, as was done with Level 2 claims. However, after reviewing and coding the transcripts, justification for these sublevels was at first seen to be flawed as

personal experience precludes scope. There were no Level 3 claims lacking scope (whether implied or expressed) in any of the transcripts. Two examples of Level 3 claims differentiated only by degree of expression of scope are:

1. Caitlyn: "Yes, I do have problems with pothole and cracks on my street." (Day 1, Line 262)
2. Leonard: "Actually, it was newly paved last year." (Day 1, Line 197)

In the first excerpt, the student included the possessive adjective "my" to define the spatial extent (scope) of where problems with potholes occur. In the second excerpt, a different student demonstrated sufficient knowledge of the topic to include temporal information to add weight to their claim.

There are three distinctive sublevels of a Level 4 claim. The first two demonstrate claims of authority by referencing outside sources. In the transcripts, these included radio or television programs, a teacher's, parent's or relative's shared expertise. Often, however, – as with the following examples – it was the supporting usage of data that determined the level of claim:

1. Eric: "…We should eat more small fish to help the population of large fish, like salmon, go up. I heard these facts on a radio broadcast." (Day 1, Line 248)
2. Keegan: "That's what they do with decommissioned naval ships; it's literally a graveyard down there in Nanaimo. My dad's dived down there." (Day 2, Line 332).

And as with Level 3 claims, the sublevels ("C4a" and "C4b") recognize the presence or absence of scope. Though not observed in the transcripts, the third sublevel, "C4c", is reserved for claims that include an appropriate analogy; a claim that

incorporates personal knowledge/experience coupled with an appropriate scope of application. The quality of a Level 4 claim that places it above the other levels (opinion and experience) is the relative defensibility it affords. The incorporation of an expert's findings into an argument demonstrates the student is not only familiar with the topic, but has the backing of an expert or experts to stand behind. If an opponent is unable to provide a similar level of support, their countering view is weakened.

The key attributes that distinguish the four levels of claims were then applied to differentiating the qualities of data and warrants using the same number of levels and sublevels with few modifications. The benefit of this uniformity was to enable the coder to more quickly memorize the level and sub-level descriptions and so simplify the challenge of differentiating the qualities of the students' assertions of claim, data or warrant, respectively. What follows is a description of the defined qualities of data and warrants with relevant examples.

Data

As with claims, determining the different qualities of data (evidence) used in the students' arguments required a detailed evaluation of the transcripts during the creation of the rubric. Since the students received no training in argumentation prior to the first recording session, even data that failed to support or negate a claim were coded ("D1a"). As the rubric shows, the three remaining sublevels of Level 1 data closely match the wording used in Level 1 claims.

Level 2 data consisted of three sublevels. The lowest sublevel ("D2a") elaborated on a student's own or their opponent's evidence. Relatively higher order

evidence noted in the transcripts grouped as Level 2 was based on a student's personal opinion without the use of scope ("D2b") and with the use of scope ("D2c"). The following example of a Level 2b data usage follows a Level 2b claim: "I think some of this land will collapse because the fresh water underground will leave, and that could be what is holding up some of the earth." (Roland: Day 1, Line 368) Here, both the claim and the supporting data are rooted in opinion, but since the evidence is not a recycled (1c), rephrasing (1d) or even elaboration (2a) of a previous claim or data, they are assigned a Level 2b, respectively. Had the student included a spatial reference (a specific location or temporal reference of where and when land subsidence is occurring), this evidence would have been coded "D2c".

Level 3 data consisted of two sublevels and since, as in Level 3 claim, the speaker is basing their evidence on personal experience, they are exhibiting a higher degree of sophistication than if their evidence was limited to an opinion. Further differentiating the quality of their argument at this level is the use of scope; the supportive detail behind which their experience is based. Evidence based on personal experience that lacked scope was assigned "D3a", while evidence based on personal experience that included scope was assigned "D3b". An example of a "D3b" data; it specified the location where the evidence is revealed is: "I have lots of potholes in the road where I live, because there aren't many drains in the road." (Eric: Day 1, Line 264)

"Level 4" evidence includes a reference to an authoritative source, or an appropriate analogy. These pieces of evidence were incrementally more advanced than those defined as lower level evidence in the rubric. That is, the speaker is able

to stand behind an explicitly referenced example that credits their data and strengthens their thesis. If scope was absent in Level 4 data, I assigned it the code "D4a". Note the following excerpt showing evidence of a student's familiarity with tidal electricity generators: "I have seen a few shows on them." (Max: Day 2, Line 201) Had the student included details on when he watched the program, or when and where the project was occurring, I would have recognized the assertion as including scope, and so assign it a code of "D4b", instead of "D4a". The following example demonstrates "D4b" data with a reference of authority a student made to support a classmate's claim: "…we watched a movie on bottled water this year, and how they used a country and took away most of its bottled water from it…" (Wendy: Day 1, Line 143).

Warrants

While declarations of one's position were highly recognizable and abundant in the discussions, and the presence or absence of supporting evidence was readily notable, too, warrants showing how the data supported the claim were less common. Warrants also presented problems in their identification, because in some cases they may be implied and not stated, and in other cases even their validity may be misunderstood from person to person. The following is an example of an explicitly stated warrant that followed a claim and two pieces of data: (Keegan: Day 1, Line 349)

With practice and refinements made to the rubric, we noted a degree of competency and consistency in differentiating the usage of data (those explanations that supported the thesis) from warrants (explanations that linked the data to the

claim). Further making their identification and classification easier, only warrants explicitly stated were coded. Locating the conjunctive adverb "so" after evidence was noted, proved to be helpful in signalling an additive, comparative or contrastive relationship. For example: "…They purposefully sink these ships and airplanes, so they can make new habitats for fish…" (Vanessa: Day 2, Line 15) Here, the independent clause of the sentence is data to support an earlier claim. The second independent clause – beginning with the word "so", provides the explanation for the relevance of the data. The rubric's defined levels and sublevels for warrants are modelled very closely after those developed for claims and data. This proved to be viable since identifiable examples of low level data and low level warrants in the transcripts were direct restatements of previously stated data and warrants, respectively. Similarly, the transcripts contained examples where students paraphrased previously stated data and warrants. Students whose data and warrants found to be a rewording or paraphrasing of a previous assertion, demonstrated greater skill and understanding than the students whose arguments merely copied previous statements verbatim. Also in the transcripts were examples of data and warrants showing the same refining characteristic of scope. Furthermore, there existed in the transcripts student data and warrants that included references of authority: "Around here they sunk that plane so divers can go explore it. My uncle went there." (Lucy: Day 2, Line 14)

Two members of my Supervisory Committee and I felt comfortable using all of the above objective characteristics for each of the three elements of argumentation used in the rubric. We collectively decided to also include the high

level cognitive skill of drawing analogies in the rubric for identifying Level 4 data and warrants. Regardless of the presence or absence of analogy in the transcripts, including this skill is important for continuity between the three rubric categories.

Argumentation Coding Rubric

Claim: (The overall thesis the speaker is endorsing, or countering)

Level C1	a. Did not relate to the topic being discussed, or b. Simply disagreed or agreed with a previous claim or counterclaim c. Reasserted almost verbatim their own, or an opponent's claim or counterclaim, or d. Rephrased their own, or an opponent's claim or counterclaim
Level C2	a. Elaborated on or revised their own, or an opponent's, claim or counterclaim b. Based on personal opinion without the use of scope (the scope of the claim lacked spatial or temporal limits or restrictions) c. Based on personal opinion while demonstrating an awareness of the scope
Level C3	a. Based on actual personal experience without the use of scope b. Based on actual personal experience while demonstrating an awareness of scope
Level C4	a. Referenced an authoritative source without the use of scope b. Referenced an authoritative source while demonstrating an awareness of the scope c. Made an appropriate analogy to strengthen assertion

Data: (Evidence gathered to either support or negate the claim, counterclaim or data – watch for the keyword "because"):

Level D1	a. Evidence did not support (or negate) the claim b. Simply disagreed or agreed with previously presented evidence c. Reasserted almost verbatim their own or an opponent's evidence d. Rephrased their own or an opponent's evidence
Level D2	a. Elaborated on or revised their own, or an opponent's, evidence b. Introduced evidence drawn from personal opinion to support or negate their claim or counterclaim without the use of scope (the scope of the data lacked limits or restrictions) c. Introduced evidence drawn from personal opinion to support or negate their claim or counterclaim while demonstrating an awareness of the scope
Level D3	a. Introduced evidence drawn from personal experience to support or negate their claim or counterclaim without the use of scope

	b. Introduced evidence drawn from personal experience to support their claim or counterclaim while demonstrating an awareness of the scope
Level D4	a. Introduced examples of evidence drawn from an authoritative source without the use of scope b. Introduced examples of evidence drawn from an authoritative source while demonstrating an awareness of the scope c. Made an appropriate analogy to strengthen assertion

Warrant: An explanation (or refutation) of why or how the data supports (or does not support) the claim – a possible indicator keyword is "so":

Level 1	a. Explanation did not demonstrate a link between the data and the claim b. Simply disagreed or agreed with a previous explanation of the data c. Reasserted verbatim their own, or an opponent's explanation d. Rephrased their own or an opponent's explanation
Level 2	a. Elaborated on or revised their own, or an opponent's explanation b. Explained how their data supported or negated the claim by drawing on personal opinion without the use of scope (the scope of the data lacked limits or restrictions) c. Explained how their data supported or negated the claim by drawing on personal opinion while demonstrating an awareness of scope
Level 3	a. Explained how their data supported or negated the claim by drawing on personal experience without the use of scope (the scope of the data lacked limits or restrictions) b. Explained how their data supports the claim by drawing on personal experience while demonstrating an awareness of the scope
Level 4	a. Explained how their data supported or negated the claim by drawing on an authoritative source without the use of scope b. Explained how their data supported or negated the claim by drawing on an authoritative source while demonstrating an awareness of the scope c. Made an appropriate analogy to strengthen assertion

Chapter 4 – Results

The grade 8 science students were recorded over three separate sessions. In the first session, 25 students working in 9 groups recorded a total of 55.6 minutes worth of discussions (an average of 6.2 minutes per group). In the second session, 24 students (1 absent) working in 8 groups recorded 43.0 minutes worth of discussions (an average of 5.4 minutes per group). During the third session, 21 students (5 absent) working in 8 groups recorded 41.9 minutes worth of discussions (an average of 4.7 minutes per group). The students presented the largest number of claims and data during the first session. Since the students had the most time to make their arguments on that occasion, simply counting the number of elements coded in the transcripts would not accurately allow comparisons to be made between the relative usage of an argument feature from the three recording sessions. Furthermore, within each session the amounts of time without any argument features or discussion related to the topics being considered varied. Consequently, I decided to:

1. Correct the length of the recording sessions by removing all sections of dead air, off-task dialogue and the reading of the discussion prompting questions from the discussion time totals
2. Calculate the relative usage frequency for each of the coded argumentation elements by dividing the total number of respective elements by the refined length of the recording session.

After applying these adjustments to the three elements: claims, data and warrants, the frequency of elements was determined and is summarized in Table 3.

Table 3
Usage frequency for each argument element

Recording Session	Total Claim/min (% of total)	Total Data/min (% of total)	Total Warrant/min (% of total)	Total Assertions/min
1 (55.6 minutes)	4.24 (50%)	3.27 (39%)	0.92 (11%)	8.45
2 (43.0 minutes)	5.12 (48%)	4.03 (38%)	1.42 (13%)	10.57
3 (41.9 minutes)	5.14 (48%)	4.09 (38%)	1.51 (14%)	10.74

Argumentation feature development over time

From Table 3 three overall trends in the distribution of claims, data and warrants were noted. First, claims were consistently the most prevalent argumentation element identified during the discussions. Second, regardless of the element (claim, data or warrant), the students collectively increased the frequency of their usage over time. Third, warrants took an increasing percentage of the argument elements assertions with each session.

Prior to analyzing the transcripts showing the students' evolving usage of claims, data and warrants, I made three claims. My first claim was that the students' ability to use the elements: claims, data and warrants, prior to argumentation instruction and Earth Science instruction was linked to them choosing to discuss their more familiar topics first. To test this prediction, I compared the aggregated students' self-assessed topic knowledge rankings with the top 4 most discussed topics. Table 4 (below) shows the students spent more time discussing the topics

they collectively (through aggregate rankings) purported to be more knowledgeable about.

Table 4
Usage rankings for sessions 1 and 2, and self-assessed knowledge rankings

Earth Science Topic	**Usage Rank**	**Knowl. Rank**	**Session 1 Usage**	**Session 2 Usage**
Sources of fresh water	1	1	7 groups	3 groups
Properties of salt and fresh water	2	3	3 groups	2 groups
Diversity of aquatic life forms	3	2	5 groups	2 groups
Productivity and species distr. in aquatic env.	4	6	1 group	6 groups

During the third recording session, the students solely discussed residential and commercial land development scenarios pertaining to Topic 5: "Weathering and Erosion". The aggregate ranking of the students' self-assessed prior-knowledge for this topic was 4th. It was, however, the least selected topic among the nine discussion topics during Sessions 1 and 2.

My second claim was that the students' would respond to the argumentation instruction and the scaffold by making more frequent usage of the argument elements. This prediction is consistent with the success of the interventions and scaffolds noted in the introduction.

My third claim was that the Earth Science concept instruction (increased knowledge of the key vocabulary, concepts and applications pertaining to the topics) and additional argumentation training (a research project with a topic pertaining to the Water Unit using an argument framework based on the Toulmin Argument Pattern), would promote greater usage of the argumentation elements. Offsetting the likelihood for this success is the removal of the scaffold going into Session 3.

The students' increase in their argumentation usage frequencies is apparent with 8.45, 10.57 and 10.74 argumentation elements stated per minute during each of the three sessions. However, this does not indicate whether the students showed a similar growth in the quality of their arguments. Did the students demonstrate an ability to string argument elements together to display the Toulmin Argument Pattern? Did the students show an increased ability to contribute ideas that showed an understanding of spatial and temporal limitations (scope), personal experience, or a reference to authority?

In order to support the above claims, I needed to direct the focus of the analysis onto the quality of the students' arguments with regard to their level and sublevel. Tables 5, 6, 7 (below) present the usage frequencies for the sub-classifications of claims, data and warrants, respectively. So for "C2b", during Session 1, the students collectively used it 94 times during 55.6 minutes of total discussion time (94 ÷ 55.6 = 1.69 assertions per minute).

Developments in the frequency, usage and sophistication of claims

Table 5
Usage frequency of claims by sublevel

Claims/minute				
	Session 1	**Session 2**	**Session 3**	**Total**
C1a	0.04	0.19	0.00	0.22
C1b	0.86	1.14	1.00	3.01
C1c	0.18	0.26	0.17	0.60
C1d	0.16	0.33	0.33	0.82
Total C1	**1.24**	**1.91**	**1.50**	**4.65**
C2a	0.63	0.54	0.86	2.05
C2b	1.69	2.07	2.41	6.15
C2c	0.29	0.33	0.29	0.90
Total C2	**2.61**	**2.93**	**3.56**	**9.10**
C3a	0.02	0.00	0.00	0.02

C3b	0.32	0.19	0.05	0.56
Total C3	**0.34**	**0.19**	**0.05**	**0.58**
C4a	0.04	0.02	0.00	0.06
C4b	0.02	0.07	0.02	0.11
C4c	0.00	0.00	0.00	0.02
Total C4	**0.02**	**0.09**	**0.02**	**0.19**
Overall Totals	**4.24**	**5.12**	**5.14**	**14.50**

Level 1 claims introducing an argument response. "C1b" assertions were consistently the most used of the Level 1 claims. Adding the total number of "C1b" claims made during the three recording sessions (48 + 49 + 42 = 139) and dividing that number by the total number of all claims made during the sessions (672) revealed 21% of all claims were "C1b". It is reported in Table 5 that "C1b" was the second most common type of claim used in each of the recordings. Prior to revisiting the transcripts, I initially interpreted the high frequencies of these simple agreements and disagreements to be sign of a lack of engagement in the discussions. As the following excerpts reveal, I was incorrect. Table 6, below, presents three typical examples of "C1b" claims pulled from the coded transcripts.

Table 6
Examples of "C1b" claims

Day 1 Line 181	Cam	I also agree with that statement C1b because of umm if you don't um, because they um can't just come in and take our water, D2b and it's just bad for them to steal our water, D1d well basically take what we have here and take it to people in other areas who probably have their own source of fresh drinking water. D2a
Day 2 Line 133	Matthew	Okay. C1b We can send water to Africa, C1c but give it to them for free. C2a
Day 3 Line 96	Ben	That seems about right, C1b but the population keeps growing, D2b so you can't stop building houses, W2b but you don't have to build them there, C2b you can build them somewhere else. C2a

In the first excerpt, Cam states his agreement with his group member's opinions with a "C1b" claim. However, he goes on to contribute evidence to back up

his agreement. In the second excerpt, Matthew is shown adjusting his previously asserted view that we shouldn't bottle our drinking water for export. His brief "C1b" assertion of agreement introduces subsequent claims that expand his full opinion. In the third excerpt, Ben states his agreement with his fellow group member's argument in part, and he goes on to explain why using evidence and a warrant. Consequently, the common usage of "C1b" claims was not an indication of low engagement. Instead it was most often a marker for the start of a series of argument features.

The usage of the other Level 1 claims (C1a, C1c and C1d) was consistently infrequent during the sessions. However, using a coding scheme that recognized the full variety of possible claims served to differentiate the students' assertions and mark usage trends. The coding scheme, in recognizing the negligible usage of "C1a" claims, for example, informed me of the students' desire to make relevant and on-topic contributions during the recording sessions. Similarly, the students' limited usage of "C1c" (reassertions of previous claims) and "C1d" (rephrasing of previous claims) indicated their preference to contribute elaborated or new ideas ("C2a" and "C2b") within their claims.

Level 2 claims and the increased usage of opinion. The second level of claims – which comprised 63% of all claims – also included three subdivisions. Lower Level 2 claims represented an elaboration of a previous assertion (2a), while the next sublevel up represented new assertions based on personal opinion without scope – spatial or temporal restrictions – (2b). The most sophisticated Level 2 claims revealed personal opinion showing an awareness of scope (2c).

My interpretation of the students' greater usage of "C2a" claims over "C1c" and "C1d" was evidence of a pattern of elaboration instead of simply repeating or copying a previously asserted claim. Brianne's speaking turn below shows her elaborating on her own claim:

Table 7
Example of "C2a" claims

Day 1 Line 14	Brianne	It comes from a well underground, C2c and it is replenished by the Cowichan River. C2a Then they clean it all, and that is when it gets to our taps, after they clean it. C2c

Topic knowledge may have played a role in the students' usage of "C2a" claims. The students made more frequent usage of "C2a" claims during Session 1 than Session 2. As I noted above, the students appear to have opted for discussing their more familiar topics during the first session. The large jump in the usage of "C2a" claims in Session 3 (See Table 5) seems to represent the students' uptake from the curriculum instruction. It seems reasonable that prior-knowledge is a prerequisite to elaborate.

The prevalence of "C2b" claims (claims based on opinion, but lacking scope) informed me that my students were willing and able to express their own ideas and opinions instead of repeating ("1c"), rephrasing ("1d") or elaborating a previously asserted claim. The high initial usage of "C2b" claims suggests stating opinions are the easiest form of argumentation for the students to assert. Also, the stepwise progression of "C2b" usage appears to show that the students could make these claims somewhat independent of their level of topic knowledge. The students' practice and improved familiarity with the elements of argumentation (through the

pre-Session 2 reflections, instruction, practice and the scaffold) likely accounted for their growth in Session 2 and Session 3 "C2b" claim usage.

"C2c" assertions throughout the study remained consistent. Topic choices, instruction and practice appear to have had no effect on the students' ability to specify the spatial or temporal limits of their claims. This result informs my future approach for argumentation instruction. Clearly, my argumentation instruction made insufficient reference to the usage of scope in helping the students convey their understanding of how their ideas and opinions are applicable to specific situations, locations and times.

Level 3 claims and the influence of question wording. The students made very few Level 3 claims – assertions based on personal experience – during the recording sessions. Equally noteworthy is the reverse trend in the usage of "C3b" claims containing personal experience that made reference to scope. The students made more than 1.4 times as many "C3b" assertions during the first recording session than the two sessions that followed, combined (0.32 versus 0.19 and 0.05). The reason for the high number of "C3b" assertions appears to be the wording I chose for three of the discussion questions; questions that specifically asked the students to share their experiences. Note the questions: "Does your family drink bottled water?" "Do you have problems on your street with potholes and cracks?" and "Where does our fresh water come from?" These discussions in response to these prompting questions resulted in 14 out of the 18 "C3b" claims during the first session, and 3 out of the 8 "C3b" claims during the second session.

I similarly interpreted the drop in usage of "C3b" claims during Session 3 to the type of questions used in the activity. The questions did not explicitly challenge the students to share their personal experiences on the topic (Topic 4: Weathering and erosion as it pertains to land use development). Instead the activity asked the students to focus specifically on an area depicted in a map provided. Had the questions asked the students to discuss their feelings on specific land use development projects happening in their communities, higher-level claims could have been noted in the Session 3 transcripts.

Level 4 claims rarely used. The highest level assigned to assertions in the study is Level 4. Claims meeting the criteria for a "Level 4" designation include a reference to an authoritative source without ("C4a") and with ("C4b") the use of scope during their presentation. The third sublevel, "C4c", requires the making of an appropriate supporting analogy. In the coded transcripts, there are very few high-level claims. Three students each made one "C4a" claim during the sessions. Of the four students who made a "C4b" claim, only one did it more than once – and did so on separate days. With the number of Level 4 assertions being so small in relation to the number of relatively lower level assertions, I am unable to describe a pattern.

Developments in the frequency, usage and sophistication of data

The students showed – as they did with claims – a progressive increase in their use of data over the three recording sessions. The frequencies progressed from 3.27 elements of data per minute in Session 1 to 4.03 in Session 2, and 4.09 in Session 3. My initial interpretation of the increases in data usage during Sessions 2 and 3 reveal two possibilities. First, it is a reflection of their increased usage of

claims. The second possibility was that the students' used progressively more evidence to support each of their (or a group member's) claims. Consequently, to determine if either or both of the possibilities explaining the changing data usage are correct, this section examines not only the students' usage patterns of data during the discussions, but also its relative usage compared to the usage frequencies of claims.

Table 8
Usage frequency of data by sublevel

Data/minute				
	Day 1	**Day 2**	**Day 3**	**Total**
D1a	0.07	0.05	0.02	0.14
D1b	0.20	0.37	0.33	0.90
D1c	0.18	0.12	0.12	0.42
D1d	0.18	0.23	0.29	0.70
Total D1	**0.63**	**0.77**	**0.76**	**2.16**
D2a	0.47	0.58	0.53	1.57
D2b	1.42	2.00	2.53	5.95
D2c	0.40	0.30	0.17	0.87
Total D2	**2.29**	**2.88**	**3.23**	**8.39**
D3a	0.02	0.00	0.00	0.02
D3b	0.27	0.28	0.07	0.62
Total D3	**0.29**	**0.28**	**0.07**	**0.62**
D4a	0.02	0.05	0.02	0.09
D4b	0.05	0.02	0.00	0.08
D4c	0.00	0.02	0.00	0.02
Total D4	**0.07**	**0.09**	**0.02**	**0.19**
Overall Totals	**3.27**	**4.03**	**4.09**	**11.38**

Level 1 data usage changes little. The students' most frequently used Level 1 data was "D1b" (a response to evidence with a simple disagreement or agreement with it). Below is a typical example of "D1b" usage:

Table 9
Example of "D1b" data

Day 2 Line 14	Brianne	Yes, I have heard of this. C3b Around here they sunk that plane so divers can go explore it. D3b My uncle went there. W3b
Line 15	Vanessa	No. D1b They purposefully sink these ships and airplanes, D2b

		so they can make new habitats for fish. W2b Artificial reefs they are called. C2b

Here we see Vanessa disagreeing with Brianne's evidence: 'artificial reefs are for habitat creation, and not for divers'. Similar to the majority of the "C1b" claims I described previously, this "D1b" data was the first in a string of related argument features. Ten out of the 16 Session 2 "D1b" data introduced new or elaborated data, claims and/or warrants. This pattern is indicative of the students' usage of "D1b" in Session 1 and Session 3. So, students who use "D1b" data to simply agree or disagree with another student's evidence are likely going to complete their speaking turn with additional higher-level argumentation features to elaborate on their position.

The students' usage of "D1c" and "D1d" data was consistently infrequent. My interpretation of the small usage of Level 1 data is that the students opted to contribute elaborated or new evidence ("D2a" and "D2b") during discussions instead of copying or rephrasing previously used evidence.

Level 2 data usage increases over time. The most frequently used data were those coded as Level 2, and most common among them: "D2b". Level 2 data comprised 74% of all data presented by the students to support (or negate) their (or a group member's) claim. Within this level, and over time, the variation in the frequency of usage is pronounced. Notably, the students' usage frequencies of data became greater than the frequency of claims over time.

My analysis of the "D2a" data usage frequencies did not reveal any student disinterest in working with or elaborating on the contributions of their group members. Instead I feel the students' purpose for adding data is predominately to

support their own claims. This perhaps explains, in part, the increased usage of "D2b" data during the second session. First of all, as I suggested earlier, the students' overall increase in "C2b" claims in the second session could be attributed to the pre-recording session classroom argumentation instructional activities and the scaffold for argument structure. The students' "D2b" usage pattern merely followed the growth in "C2b" usage; as the students made more claims, they added more data to support those claims.

The students' usage of data, and "D2b" data in particular, increased to the point of becoming the most frequently used argumentation element in Session 3. Earth Science concept instruction is a plausible explanation for the students' high frequency of "D2b" assertions during the final session. The third recording session was a tremendous opportunity for the students to contribute data from their learning about the topics in lessons 5, 6 and 7 to the discussions.

Level 3 data and the influence of question wording. The students used "D3b" data to support the claims with near equal frequency during Sessions 1 and 2 (0.27 and 0.28 data per minute, respectively). The frequency, however, fell to 0.07 data per minute during Session 3 (Table 10, below). During my interpretation of the drop in Session 3 "C3b" claims, I mentioned the questions used during the Session 3 recordings did not explicitly challenge the students to share their personal experiences on the topic (Topic 4: Weathering and erosion as it pertains to land use development). I believe this explanation can be used to describe the drop in "D3b" data usage. Had the questions asked the students to discuss their feelings on specific

land use development projects happening their communities, higher-level data could have been noted in the Session 3 transcripts to support their claims.

Table 10
Usage frequency of level 2 and level 3 data by sublevel

Data/minute				
	Day 1	**Day 2**	**Day 3**	**Total**
D2a	0.47	0.58	0.53	1.57
D2b	1.42	2.00	2.53	5.95
D2c	0.40	0.30	0.17	0.87
Total D2	**2.29**	**2.88**	**3.23**	**8.39**
D3a	**0.02**	**0.00**	**0.00**	**0.02**
D3b	**0.27**	**0.28**	**0.07**	**0.62**
Total D3	**0.29**	**0.28**	**0.07**	**0.62**

Level 4 data rarely used. The students infrequently included data that made an analogy or a reference to an authoritative source (Level 4). Only one example of "D4a" data – data that omitted scope – was present in the first and third recording session, and two in the second recording session, respectively. I could note no patterns explaining the usage of high-level evidence. They occurred similarly infrequently during the first and second sessions (argumentation training was not an influencing factor) and unrelated to the students' purported prior knowledge rankings.

Developments in the frequency, usage and sophistication of warrants

Warrants were the least frequently applied element of argumentation in this study. It required the students to provide an explanation for their (or their group member's) selection of data that supported a claim. Even when the students prepare their science reports, I noticed their difficulty in making these connections – despite having time to reflect on their hypotheses, observations and results. Perhaps compounding the students' difficulty in crafting warrants was the design of this

study. These oral discussions afforded the students an insufficient amount of time to reflect on their claims and data in order to craft an explanatory link (warrant). Consequently, the number of warrants in the transcripts that make up the frequencies of are too few to allow a reasonable interpretation of patterns to be made at the sub-level. Nevertheless, as with the other elements, the students' overall usage frequency of warrants increased from session to session (Table 11, below).

Table 11
Usage frequency of warrants by sublevel

Warrants/minute				
	Day 1	**Day 2**	**Day 3**	**Total**
W1a	0.02	0.05	0.00	0.06
W1b	0.02	0.07	0.05	0.14
W1c	0.00	0.07	0.00	0.07
W1d	0.02	0.00	0.10	0.11
Total W1	**0.06**	**0.19**	**0.15**	**0.38**
W2a	0.14	0.16	0.22	0.52
W2b	0.49	0.72	0.96	2.16
W2c	0.05	0.19	0.17	0.41
Total W2	**0.68**	**1.07**	**1.35**	**3.09**
W3a	0.02	0.00	0.02	0.04
W3b	0.11	0.12	0.00	0.22
Total W3	**0.13**	**0.12**	**0.02**	**0.26**
W4a	0.02	0.00	0.00	0.02
W4b	0.04	0.02	0.00	0.06
W4c	0.00	0.02	0.00	0.02
Total W4	**0.06**	**0.04**	**0.00**	**0.10**
Totals	**0.92**	**1.42**	**1.51**	**3.84**

In Session 1, perhaps due to the freedom of being able to choose from the nine discussion topics, 18 out of the 25 participants (72%) were able to make at least 1 warrant during the discussions. In Session 2, with argumentation instruction and a scaffold, 18 out of the 24 participants (75%) included at least 1 warrant; a negligible change in the overall students' ability to make a warrant. However, the total frequency of warrant usage did increase during each session. This result

suggests the scaffold did not draw a significantly higher percentage of students to include warrants during the discussions, but it appears to have enabled the students capable of making warrants to make more warrants.

Finally, in Session 3, after receiving Earth Science instruction, additional argumentation practice, but no access to a scaffold, all 21 participants included at least one warrant. The students' willingness and ability to respond to the instructional interventions lead to the overall increase in the frequency of warrant usage throughout the sessions. It also supports the overall claim that Earth Science concept and argumentation skill instruction contributed towards the increased overall usage of all three elements of argumentation – even with the removal of the scaffold.

Table 12
Overall usage frequencies of the three argument elements

Element	Session 1	Session 2	Session 3	Total
Total Claims	**4.24**	**5.12**	**5.14**	**14.50**
Total Data	**3.27**	**4.03**	**4.09**	**11.38**
Total Warrants	**0.92**	**1.42**	**1.51**	**3.84**
Total Elements	**8.43**	**10.57**	**10.74**	**~29.72**

Displays of the Toulmin Argument Pattern. In this study, in order for students to successfuly demonstrate the Toulmin Argument Pattern (TAP) within one speaking turn they had to string together supporting data and linking warrants to a claim or claims. Given the low frequencies of warrants, I predicted the transcripts would reveal few to no TAP displays within a speaking turn. My analysis proved this prediction incorrect. During Session 1, 32 out of the 51 warrants (63%) made during the session were part of a student's TAP display. 16 out of the 25

participating students (64%) demonstrated the ability to make at least one TAP within a speaking turn during that time.

Going into Session 2, after receiving argumentation instruction and a scaffold, the students' TAP displays increased in line with the increase in warrant usage frequency. 49 out of the 61 warrants (80%) made during the session were displays of TAP within one speaking turn. However, a similar number of students, 14 out of the 24 participants (58%), contributed to the making of these TAP displays.

The trend of TAP displays during Session 1 and Session 2 matched the trend of warrant usage: the scaffold did not enable a higher number of students to make displays of TAP during the discussions. The scaffold appears to have enabled the students capable of making TAP displays to make more TAP displays.

I predicted the students would make the most displays of TAP during Session 3. They were familiar with the recording discussion routine, and they presumably had a greater knowledge of Topic 5 ("Weathering and Erosion") having worked through the classroom Earth Science instructional activities. The students were also familiar with the Toulmin Argument Pattern through their two discussion experiences and their research project. However, the students would not be able to refer to the scaffold that appeared to enable a greater number of warrants and displays of TAP during Session 2. In Session 3, the transcripts revealed 35 out of 64 warrants (55%) were part of a TAP within a speaking turn; the students made slightly more warrants but fewer TAP displays than in Session 2.

Despite the overall drop in TAP displays during Session 3, more students were able to make at least one display of TAP (17 out of the 21 participants) than either of the previous two sessions. This reflects the high number of students making warrants during Session 3 (21 out of 21 participants).

These results suggest that without the scaffold, the students were not able to make the same number of TAP displays within a speaking turn in Session 3 than in Session 2. Topic knowledge does not seem to contradict this finding since more students were able to make warrants and displays of TAP. That is, the increased level of topic knowledge enabled more students to make more warrants, and individually more TAPs, but the lack of a scaffold may have prevented an overall increase in TAP displays.

Summary of the results

This chapter revealed the students' evolving usage of claims, data and warrants over the three sessions. The trend points to an overall progression in the students' ability to include these three elements of argumentation – at the "2b" level. Referring to the three claims presented in the opening of the chapter (and again below) I offer the following evidence.

1. The students' ability to use the elements: claims, data and warrants, prior to argumentation instruction and Earth Science instruction, was linked to them choosing to discuss their purportedly more familiar topics first.
2. The students responded to the argumentation instruction and the scaffold by making more frequent usage of the argument elements.

3. The Earth Science concept instruction and additional argumentation training promoted greater usage of the argumentation elements.

Evidence supporting Claim 1. Prior to Session 1, I presented the students with a handout that asked them to independently self-assess and rank their prior-knowledge of the nine Earth Science discussion topics. The aggregated rankings of the students' top 3 topics were: "Sources of fresh water", "Properties of salt and fresh water" and "Diversity of aquatic life forms". During Session 1 the students, who were free to choose the order of the topics they discussed, opted to discuss those three topics most. 70% of the Session 1 discussions (39.1 out of 55.6 minutes) were spent on those three topics. Providing the students' with a choice created a discussion environment where the students spent less time struggling to come up with relevant ideas and more time on applying their prior-knowledge.

Evidence supporting Claim 2. The students' high usage of Level "2b" elements throughout the discussions suggests the basing of argument elements on opinion is the easiest form of argumentation. However, the stepwise progression of the students' Level "2b" element usage during the three sessions indicates they could apply the argumentation instruction and scaffold regardless of their level of topic knowledge.

Evidence supporting Claim 3. The students' highest usage frequencies of the three argument elements came during Session 3. However, it was the students' progress in their ability to use warrants and make a TAP display that provided the greatest evidence supporting the third claim; 100% of students demonstrated an ability to use warrants and 81% could make a TAP during Session 3. However,

without a scaffold to guide their usage of the argument elements, the students showed a reduction in the total number of TAP displays.

While the students did demonstrate a stepwise progression in their overall claims, data and warrant usage frequencies during the three sessions, I did not examine the characteristics of the students' interactions with each other, and the influence these may have had on their TAP usage. Therefore, in order to more fully explain the students' individual argumentation patterns, I felt compelled to examine the quality of their discussions and the role of group dynamics. Given the number of students participating in this study, it was necessary for me to select a representative sample to learn how the students interacted during each of the sessions. The Analysis section below presents these efforts and the findings they revealed.

Chapter 5 – Case Study Analysis

Case study of five students

The Results section reviewed and interpreted the students' usage patterns of the argumentation elements collectively over three recording sessions. The results found evidence supporting the three claims relating to the influence of:

- Topic familiarity
- Argumentation instruction and a scaffold on applying the elements
- Earth Science instruction and additional argumentation training

Missing from that analysis was an investigation of the students' small group interactions. After an initial review of the transcripts, I established the following three questions to guide a smaller scale analysis:

- Did any of the students invite or challenge members of their group to participate in the discussion or elaborate on their position?
- Were oppositional or collaborative arguments more influential in extending discussions?
- Was there evidence of a student's enthusiasm encouraging the other group members to take a greater role in the discussion?

To answer these questions, this section provides a more detailed description of the individual performances of five selected students: 3 'high' performing, 2 'low' performing with one that showed the greatest gain will be presented. Of the five students in my entire class who on average applied more than two argument elements per minute over the three recording sessions, only three were consistently

high. The frequency of applied elements for these students (Students A: “Annie”, B: “Ben”, and C: “Caitlyn”) are shown in Table 13 and 14 below.

In selecting the students who displayed lower frequencies of elements my task proved to be more challenging. Six students had similarly low element usage frequencies. The first student I selected displayed the lowest element frequencies in the first session, yet jumped dramatically and consistently with each lesson to finish with the second highest frequency of elements in the third session. I was curious to see if her improvement could be evidence supporting one or more of the above three claims. The results for this student (Student D: “Dana”) are shown in Table 13 and 14 below.

Table 13
Case study students' participation during the sessions

	# Turns (Times spoken)				**Turns/minute**			
Name	**Day 1**	**Day 2**	**Day 3**	**Avg.**	**Day 1**	**Day 2**	**Day 3**	**Avg.**
Student A “Annie”	15	18	9	**14**	2.05	2.62	2.65	**2.44**
Student B “Ben”	14	16	21	**17**	1.92	2.33	2.96	**2.40**
Student C “Caitlyn”	8	19	7	**11.3**	2.40	2.32	2.06	**2.26**
Student D “Dana”	1	14	10	**8.3**	0.30	1.71	2.94	**1.65**
Student E “Eric”	5	7	8	**6.7**	1.50	0.86	1.48	**1.28**
Average				**11.46**	**1.63**	**1.97**	**2.42**	

Table 14
Case study students' selected discussion topics

	Topics Spoken		
Name	**Day 1**	**Day 2**	**Day 3**
Student A “Annie”	5, 9, 4	8, 1, 2, 6	5
Student B “Ben”	5, 9, 4	8, 1, 2, 6	5
Student C “Caitlyn”	9, 3, 4	2, 1, 8	5
Student D “Dana”	9, 3, 4	2, 1, 8	5

Student E "Eric"	9, 3, 4	2, 1, 8	5

Four students in the study displayed frequencies less than or equal to 2.0 in each of the three sessions. However, it was necessary to remove two of these participants from this shortlist because their performances may have been negatively influenced by audible detracting comments made by one of their respective discussion group members. While a significant and worthwhile topic, the influence of negative peer support is not a focus in this study. This left two students meeting the low frequency criteria.

Upon closely analyzing the transcripts I realized some of the discussion groups covered as many as four discussion topics while two of the groups covered just one during each of the first two sessions. Since I needed to look for the affect of topic knowledge on the students' element usage frequencies, groups whose discussions focused solely on one or two topics each session would not provide sufficient backing. I counted the number of topics each of the discussion groups covered in the first two sessions. Three groups discussed no fewer than three topics during each of the first two sessions. One of these groups contained students having neither high nor low assertion frequencies. Consequently, the criterion that a minimum of three discussion topics must be discussed during each of the first two sessions enabled the selection of my final student for the case study: Student E ("Eric").

My final test of the selection criteria for the five students in the case study was to determine whether their usage of the argumentation elements: claim, data and warrant matched their usage frequencies. I needed to be certain that students

who appeared to be using a high frequency of elements were not simply making single sentence interjections. Similarly, I needed to demonstrate that the students I labeled as showing low frequencies of elements did not make multiple usage of claims, data or warrants within the same utterance. Table 15 below reveals the results. Despite the comparatively high frequency of claims by Eric during the first session, and the comparatively high frequency of data by Dana during the third session (both to be examined later), the combined averages of each of the five students reinforced the division my case study criteria made between the students displaying high element usage frequencies and the students displaying low element usage frequencies.

Table 15
Case study students' usage frequencies of the argumentation elements

	Freq. of Claim usage			**Freq. of Data usage**			**Freq. of Warrant usage**			**Avg. Assert.**
Name	**Day1**	**Day2**	**Day3**	**Day1**	**Day2**	**Day3**	**Day1**	**Day2**	**Day3**	
"Annie"	1.37	1.60	2.68	1.09	2.47	3.01	0.41	0.58	0.70	**4.67**
"Ben"	1.23	1.89	3.53	0.96	1.45	2.35	0.96	1.45	0.29	**4.71**
"Caitlyn"	1.80	1.47	1.18	2.40	2.32	2.06	1.20	1.10	1.47	**5.00**
"Dana"	0.3	0.61	1.77	0.30	1.10	2.06	0	0.24	.029	**2.22**
"Eric"	2.70	0.73	1.11	1.80	0.73	0.74	0.60	0	0.37	**2.93**
Average	**1.48**	**1.26**	**2.05**	**1.31**	**1.61**	**2.04**	**0.63**	**0.67**	**0.57**	

I paid no attention to discussion groupings while developing the selection criteria for this case study. However, the selected students were at times in the same discussion group. Annie and Ben were part of the same group of three during the first two sessions, but separate during the third session. Caitlyn and Dana were in the same group of three during all three sessions. The discussion groupings contained students displaying both "high" and "low" frequencies of assertions. The

relative element usage development over time of the students not among the selected five (Annie, Ben, Caitlyn, Dana and Eric) was not analyzed. However, their contributions and general influence during the discussions provided useful evidence for the claims established in this thesis. I assigned the students who were present in a discussion group with any of the above five case study participants, the following pseudonyms: Martin, Michael, Jenny, Leonard and Roland. The selection of these pseudonyms is not an indication of their level of participation or skill at using Toulmin's elements.

The five case study participants: Annie, Ben, Caitlyn, Dana and Eric

Annie is an attentive, thoughtful and determined student who earns high marks. While she shares her ideas and experiences in general class discussions, she prefers working independently or in small groups with her friends. I was, therefore, surprised to determine Annie participated with the highest and the most consistently increasing average frequency among the students during the sessions. In none of the recording sessions did Annie work in a group containing close friends.

Ben is thoughtful and capable as well. He contributes less frequently during science class discussions, yet appears to enjoy problem solving and completing science lab activities in groups. Ben, at times, completes his assignments and reports with less detail and organization than I expect from him. Ben's average for the term was 72% (1% lower than the class average). Yet the analysis of the discussion transcripts revealed that he contributed the second highest frequency of argument features in the class for the three recording sessions. Although his degree of contribution of argument features appeared to contradict his science grade for the

term, I had many opportunities to converse with Ben about science topics during noon hour and recess supervisions and learned he is interested in science and comprehended the concepts and their relevance very well. This may be a case of a student who likes science but is less interested in school generally.

Caitlyn is a keen student who is eager to offer answers and ideas in class and has perhaps the strongest work ethic. She consequently has the highest academic average among her peers in Grade 8 science. Caitlyn's career interests lie in a field of science, specifically, marine biology – the field of her parents.

Dana was included in the case study because of her dramatic increase in argumentation element usage frequencies from the first recording session to the second. Dana, academically, is consistently among the top 3 in science. She is reluctant, however, to participate in oral discussions or presentations. Dana is very personable and witty among her peers and teachers.

Eric participated in each of the three recording sessions, but with consistently the lowest average frequency. Eric's participation in science class discussions is similarly infrequent. Among the other students considered for the case study, Eric had the lowest academic average in Science going into the study with 67%. These results, however, do not necessarily represent his true cognitive ability. Throughout the term, Eric displayed moments of excellent comprehension of the concepts. He is a student whose motivation peaks and wanes.

Michael, though not one of the case study participants, worked with Annie and Ben during the first two sessions. His performance during the first two recording sessions mirrored his behaviour in the class; that is, Michael is a quiet

student who, despite working on an individual education program (IEP) for dysgraphia and fine motor control, displays good understanding of the concepts through his oral responses. The recording sessions were a great opportunity for him to perform using his oral talents. Unfortunately, his willingness to contribute to the discussions was hampered during the third session because one of his group members repeatedly stopped him from fully sharing his ideas. Consequently, I couldn't gauge accurately his argumentation development, and he was removed from the case study selection process.

Session 1: Case Studies Annie and Ben with Michael. During the first recording session, Annie, Ben and Michael opted to discuss the topics: 5 ("Weathering and erosion"), 9 ("Diversity of aquatic life forms") and 4 ("Effect of water and ice on surface features"), in that order. Based on Annie's self-assessed prior knowledge rankings, she ranked these topics: 2nd, 8th, and 1st, respectively. Ben, on the other hand, assigned the following ranks: 2nd, 1st, and 6th, respectively. Michael ranked these topics: 3rd, 9th, and 8th, respectively. Interestingly, all three students ranked "Weathering and erosion" highly in their prior knowledge.

While discussing Topic 5, Ben and Annie asserted themselves equally. They each were able to start one of the two Topic 5 discussions by making opening assertions of claim. They both gave supportive responses to each other's arguments. Michael took two speaking turns during the Topic 5 discussions. Each turn contained a single Level 2 claim.

At no point during the Topic 5 discussion, did any student contribute either a countering claim or data to challenge the other's argument; all of the arguments

were accepting, or an elaboration of a previous argument. Annie's speaking turn, shown below on Line 45, was the only time during the Topic 5 discussion anyone from the group made a display of TAP or linked supporting data and an explanatory warrant to a claim. This argument, demonstrated Annie to be comparatively skillful at constructing an argument prior to receiving argumentation instruction in class.

Table 16
Example of TAP

		What are some of the consequences of removing trees?
Day 1 Line 44	Ben	More mudslides. C2b
45	Annie	Yeah. C1b If there are no trees, there are no roots holding the ground together, D4b just like a video I saw. W4b
46	Ben	Yeah I saw that. W1b It was awesome. W2a
47	Michael	Erosion is like what happened to the Grand Canyon. C2c

The discussion that ensued between Annie and Ben with the second topic (Topic 9) was similarly balanced with regard to the number of elements used, with some exceptions. This time Ben, who assigned Topic 9 the highest ranking (1st), initiated both of the discussions with opening claims, and showed sufficient confidence to be the first to disagree with a group member's (Annie's) elaborative claim by making a counterclaim (see to Lines 51 and 53 below). Annie, however, maintained her position and refuted Ben's counter – without providing supporting evidence. This brief exchange showed Ben initially committing to and then moving away from his position. It reveals Ben could recognize an inferior claim or incorrect evidence and refrain from becoming obstinate.

Table 17
Examples of countering claims

Day 1 Line 49	Ben	A food web is like the other form of a food chain, except it is a like a circle. C2b
50	Annie	Humans are usually in the center. C2b
51	Ben	Uh, no. Humans are not in the center. C1b

52	Annie	Yeah, we are. C1b
53	Ben	There are no humans in Antarctica. D2b
54	Annie	Yes, there are. D1b
55	Ben	Okay. D1b You're right. D1b Next thing.

Annie's contributions to the discussion appear to have moved from being collaborative (Line 45) to oppositional (Line 60) in nature in response to Ben's opening assertion.

Table 18
Examples of collaborative and oppositional responses

Day 1 Line 57		*What impacts do you think we are having on the food web and diversity in our lakes, rivers and oceans?*
Line 58	Ben	Basically, if you take an animal out of the ecosystem it is going to mess up some stuff. C2b
59	Michael	Like what happened with salmon. D2b
60	Annie	Give me proof. What would happen?
61	Ben	What would happen? Okay. The bears starve basically, because they don't have enough fish to eat. W2b
63	Michael	What about honey? D2b
64	Ben	Bears don't eat that much honey, actually. D2b Also, a lot of creatures in the ocean would, like, lose their food. D2b
65	Annie	Like killer whales. W2b
66	Ben	Like if the seals weren't eaten every year, then they would kill too many salmon. W2b
68	Annie	Or, if all of the seals died because there weren't any salmon, the whales wouldn't have any food, either, D2b and they would also die. W2b

Ben, however, met Annie's challenge for proof by providing a supportive warrant (See Line 61) linking Michael's usage of data to support his opening claim (Ben's first demonstration of TAP). The elements that followed revealed a continued interaction and collaboration between Michael and Ben.

Annie's challenge for clarification was significant in that it helped extend and enrich the discussion. Compared to Ben's earlier topic discussions, his argument sophistication improved to include warrants.

The final topic the group selected for discussion was Annie's highest-ranking topic (Topic 4). Her sophisticated opening turn contained a series of argument elements (an excellent example of TAP):

Table 19
Example of a sophisticated TAP display

		Topic 4: Effect of water and ice on surface features
Day 1 Line 71	Annie	My point is that if there is a tsunami, it would destroy the landscape and take all of the trees, houses and everything; C2b it would create pollution in the water C2b because it would have dirt and stuff in it. D2b Probably a lot of fish would die, C2b and that would affect a lot of things in the food web. W2b
73	Ben	I basically disagree, C1b because you would have to have endless tsunamis to change things like that. D2d Just one tsunami is not going to change natural features and stuff. W2b

While being Annie's second TAP display of the discussion, this example contained an opening claim not derived from another opponent's contribution (the opening assertion in her first TAP was an elaboration of Ben's opening claim). This speaking turn contained the only topic-opening claim that included additional supportive elements (two claims, data and a warrant). In this turn, Annie seemed to be applying the same expectation she had of her group members; she provided "proof". She may have become accustomed to, and so anticipated Ben making an oppositional response. However, Ben still countered this speaking turn with his own complete TAP (Lines 71 and 73). The source of the disagreement between the two, in the above excerpt, appeared to be a difference in interpretation of the word "landscape".

In this first session, the group's usage of data and warrants was most evident when there was disagreement, or when challenged to elaborate. Also, when one student (in this case Annie) contributed a warrant or complete TAP display the

other students responded with similar elements. This provides evidence to support the first two focus questions:

- Did any of the students challenge members of their group to participate in the discussion or elaborate on their position?
- Were oppositional or collaborative arguments more influential in extending discussions?

The results also suggest that the usage of warrants and displays of TAP by one student has a modeling effect on the other students.

Session 2: Case studies Annie and Ben with Michael. Annie, Ben and Michael grouped themselves together again for the second session. This time they opted to discuss the following four topics: Topic 8 ("Productivity and species distribution in aquatic environments"), Topic 1 ("Sources of fresh water"), Topic 2 ("Properties of salt water and fresh water"), and Topic 6 ("Evidence and effects of glaciation"), in that order. While Ben and Michael professed a higher level of prior knowledge, Annie demonstrated a higher level of argument structure. The transcripts revealed both supportive and intriguing evidence.

Unlike the first recording session, when both Ben and Annie made a similar number of opening claims, Annie made all but one opening claim during the second session, and so guided the direction of the topic discussions. Furthermore, all of these opening statements included at least one supporting piece of data. This is a marked improvement over her Session 1 opening statements (see above) and demonstrated a possible transference of the argumentation skill instruction the class received and the helpfulness of the argument scaffold.

Annie's growth in argumentation skill is also evident in how she again challenged her group members to make countering claims even though she purported to be less familiar with the topic (Topic 8 ranked 7th). Furthermore, Annie's use of the word "claim" on Line 55 further reveals her uptake of the terminology introduced to her prior to the start of the session. Annie's session opening speaking turn starts the discussions with a claim, evidence and a challenge.

Table 20
Examples of high usage frequencies of argument elements

Day 2 Line 55	Annie	So, I claim that it is not good for us to put artificial reefs in the ocean, C2b because it is not a real natural environment. D2b Does anyone have something to say about that?
56	Ben	I disagree. C1b I think it's fine C2b unless there is something left in the airplanes. C2a
57	Michael	Like fuel. C2a
58	Ben	Yeah, like fuel C1c. But other than that it is fine, C2a because it can help to make a new environment. D2b For example, it may help keep the eggs away from sharks, and stuff. W2b
59	Michael	If it is painted, it shouldn't have lead paint in it. C2b
60	Ben	Yup. C1b
61	Annie	Also, like if it was metal, the salt in the ocean would corrode it, break it down, and the rust would get into the water, D2b and that wouldn't be good for the fish and the coral, and stuff that is growing on whatever they sink. W2b

Ben also seemed to be applying his argumentation skill training and the scaffold. The majority of the claims he made included contributions with elaborative details, supportive evidence or warrants. For instance, during the first topic discussion, he made the group's only full display of TAP (Line 58). Annie, however, maintained her original claim and responded to Ben's pro-artificial reef argument contributions, by adding supporting evidence and a warrant (Refer to Line 61).

The following excerpt appears to show that even if there is a challenge to elaborate, when the students' share a common opinion the discussion is short lived.

Table 21
Examples of shared opinions

Day 2 Line 68	Annie	Okay, my claim is that, I don't think bottling companies should be able to take water from local rivers C2b, because the fish need that water, D2b and some people need to drink from it D2b. The company is just taking the water that we could get anyway, D2b and they are making us pay for it. D2b
69	Ben	I agree. C1b
70	Annie	Why do you agree?
71	Ben	Because it is kind of stupid how they have water companies and stuff. D2b So, yeah, I totally agree. W1a

Even though Annie's challenge was successful in getting Ben to elaborate by completing a TAP (though low-level) the discussion lasted only 1.3 minutes; each group member made just one C1a assertion before ending the discussion. No one opposed a group member's claim. I interpreted the short discussion length and limited elements to the lack of an opposing point of view. The analysis seems to be pointing to a trend that the usage of argumentation features is dependent upon contrasting points of view. Incidentally, Annie and Ben ranked Topic 1 similarly (4^{th}).

During the Topic 2 discussion, Annie (who ranked this topic 9^{th}) demonstrated the power firsthand experience has in swaying opinion. Every Christmas Holiday, Annie goes with her parents to an area with a warm climate. Annie shared with me that in the year preceding this study she went to Aruba. Apparently this experience provided her with an introduction to the importance of desalination plants in areas that receive little rainfall or have insufficiently large watersheds to meet the demand for water. The following is the pertinent excerpt from the recording session on the feasibility of making fresh water out of salt water.

Table 22
Example of firsthand experience

Day 2 Line 83	Annie	Yes, that is possible, C2b because there are desalination plants that boil the salt water to make drinking water. D2b
85	Michael	I think it is just a way for them to make money. C2b
86	Annie	Yeah, C1b but on islands and stuff, they need these plants, C2c because they don't have big lakes and they can't have rivers. D2c
87	Ben	You can have a river on an island. D2b
89	Annie	Where does the water come from?
92	Ben	Okay, okay, C1b but where does the fresh water come from?
93	Annie	Precipitation. Db
94	Michael	It also comes from the snow that is on top of the mountain. D3b
96	Ben	Yes, it comes from precipitation, indeed. D1c So there is fresh water. W2b
97	Annie	To sustain a whole island with just rainwater wouldn't really work. C2b
98	Ben	Well, how big is the island?
99	Michael	If it were on Vancouver Island, it would be enough. C2c
100	Annie	You see Aruba wouldn't have enough. C2c It's an island, D3b and they actually have a desalination plant, D3b because they don't have freshwater at all. W2c They don't have mountains… W2c

As Lines 85 and 87 reveal, neither Michael nor Ben thought of the possibility of a desalination plant, whereas Annie (see Line 100) has this knowledge as a result of her trip to Aruba. While Ben applied his prior knowledge of the water cycle in an attempt to weaken Annie's argument, she held onto her position and cemented her case with a claim and a series of Level 3 data and warrants (TAP). In light of the evidence, Ben chose not to counter, and the discussion ended.

Upon comparing Ben's usage of TAP during the Topic 8 discussion and this discussion, I noticed a regression. When Annie made her argument on desalination plants, Ben chose not to address her claim or data. He instead delayed his entry into the discussion until he could introduce his understanding of the water cycle to counter Annie on a separate matter (Lines 87 and 92). So while the oppositional nature of Ben's arguments remained, his lack of familiarity with Annie's opening

argument weakened his ability to respond with similar detail. Ben's participation in the discussion appears to show that students inherently assign greater weight to evidence derived from personal experience over evidence acquired via classroom instruction.

The group, during the final discussion of the second session, considered the evidence and effect of glaciations on the landscape (Topic 6). As with the Topic 1 discussion, the Topic 6 discussion was brief and collaborative; however, the students didn't simply agree with one another. Instead, they worked together to build their ideas.

As mentioned above, Annie and Michael ranked this topic highly (3rd and 2nd, respectively), while Ben ranked it 7th among the nine topics. Michael and Annie took control of this collaborative discussion by introducing the keywords: "condense" and "compressed" to describe the effect of an ice sheet's weight on the land beneath it. Refer to the discussion below:

Table 23
TAP usage and purported topic knowledge

Day 2 Line 103	Ben	If a thousand metre thick sheet of ice was on the ground, it would put a lot of pressure on the ground, C2b so the ground would like…
104	Michael	It would condense. D2b
105	Ben	– I guess. D1b After like a long time, it would be like morphing. D2b
106	Annie	Actually, it would be compressed. D2a
107	Ben	Yes. I guess. D1b
108	Michael	So, places where there are actually glaciers, there's usually mountains on either side because of what Sam said. W2b
110	Annie	Also, if it was on Vancouver Island, I don't know how it could still be here, C2c because it would be so compressed, D2c and it's an island. W2c
111	Michael	It would sink. D2c
112	Annie	Yeah, D1b it wouldn't be here. C1d

113	Ben	We must have been higher than we are now. C2c

Michael's best arguments of the session came during this short discussion. He made a display of TAP by contributing evidence (Line 104) and a warrant (Line 108) to Ben's opening claim (Line 103). Furthermore, Michael showed his greatest involvement in this session by taking three out of the ten speaking turns. Annie and Ben accepted and used these contributions to scaffold their own position. Annie contributed the only complete TAP or string of claim – data – warrant within a single speaking turn during this topic discussion (See Line 110). I could see no evidence of Michael's element usage being the result of either Annie or Ben modeling the argument structure. Topic knowledge appears to be having the greatest influence on his contributions.

In the second session, Annie and Ben displayed growth with regard to their linkage of elaborative claims, supporting data and warrants to their initial claims. This development points to a possible transference of the argumentation instruction that preceded Session 2, and the presence of a scaffold for reference. The group's interactions continue to indicate the usage of argumentation features is dependent upon contrasting points of view. Annie's successful use of challenges or prompts to get her group members to elaborate on their assertions or evidence also continued in Session 2. New from the Session 2 results, however, is the greater relative weight evidence derived from personal experience has over evidence drawn from general background knowledge.

Session 3: Case study Annie with Mark and Matthew. Annie and Ben worked separately during the Session 3. Annie was in a discussion group with two

boys: “Mark” and “Matthew”. The session focused solely on land development as it pertains to Topic 5: “Weathering and Erosion”. As I outlined in the Methodology section, the session took place after the Earth Science classroom and lab activities. Consequently, I expected the participants would include greater concept understanding and more of the relevant Earth Science vocabulary in their usage of claims, data and warrants.

Mark and Matthew’s term evaluation averages of 78% and 60%, respectively, could lead to the assumption that Mark is the more able science student. In actuality, from an oracy standpoint, Matthew demonstrated numerous times throughout the term during presentations and class discussions to be the stronger student. Mark is quiet in class and struggles with organization and assignment deadlines. Matthew, on the other hand, is on an adapted Independent Education Program for behaviour. Without adaptations, the pressures of following instructions, assignment deadlines and homework expectations can prove to become overwhelming sources of stress. That said, Matthew is very bright, articulate, and has a strong desire to lead. I expected the recording sessions would be an opportunity for him to shine.

Mark and Matthew worked in separate groups during the first two sessions. During the first session, their respective groups’ discussions lasted approximately half the class’ average of 6.2 minutes. However, Matthew differentiated his performance from Mark during Session 1 by being the group member with the most argument elements (Mark participated in the discussions least in his group). During the second session, Matthew’s group again discussed the topics more briefly, and with fewer examples of TAP, than most of the other groups. Mark’s group for the

second session was much more conversant discussing the topics for 5.0 minutes (approximately the class average). Compared with Annie's contributions during the first two sessions, though, Mark and Matthew's usage of the argument elements was less frequent.

Annie's approach to leading discussions continued in Session 3. She initiated five out of the seven discussions and contributed nearly twice as many argument elements as either Mark or Matthew (20 versus 11 and 12, respectively). Further, she continued including at least one piece of data to support each of her opening claims.

Annie's usage of the elements was more accommodating and collaborative with her new group. I took an excerpt from early in the discussion to show a typical exchange. The students were discussing possible solutions to the proposal of building a small group of houses near a lake.

Table 24
Examples of data supporting a claim and an invitation to participate

Day 2 Line 124	Annie	They could build it further back if they wanted, C2b or they could plant some trees, close to the river to hold the dirt. C2b The roots will hold it in better and absorb more moisture. D2b How about you, Matthew?
125	Matthew	They could probably build some irrigation system to collect the water and bring it down to the river. C2b
126	Mark	Oh yeah. C1b
127	Matthew	Something that could possibly move the collected water. C2a
128	Annie	Yeah, that's good. Okay. C1b
130		*The forest on the other side of the river will be clear-cut; entirely logged the replanted.*
131 & 132	Annie	That would have a major effect on the whole ecosystem there, C2b because the trees are shelters for the animals, D2b and the rain. D2b And also, since it is on a slope that will cause landslides. C2b It is near the mountain, so there will be a lot of precipitation, D2b and the absorbency would go down, W2b and there would be floods. W2a

133	Matthew	But aren't they replanting trees? D2b
134	Annie	They are, D1b but that does not have the same effect, C2b because animals can eat them because they are small. D2b The roots won't hold onto the dirt as much because they are little baby trees. D2b
135	Mark	It will take years for them to grow. D2b
136	Annie	Yeah. D1b Some of these trees could be hundreds of years old, depending on how old this forest is. D2b
137	Matthew	So, as old as my grandmother? D1a
138	Mark	Yeah, sure, D1b maybe even older. D2a
139	Annie	Yeah. D1b

Annie invited her fellow group members with an increased frequency during the previous two sessions. In this session, the only example of this came from Annie early in the session (refer to Line 124). In response to this invitation, Matthew's reply included two relevant claims (refer to Lines 125 and 127). This was the first of only three times during the session that he strung together more than one element into a speaking turn. Consequently, Annie's invitations to contribute – were drawing additional claims and evidence from her new group members as well. However, the implications of Annie's overall accommodating and collaborative approach in Session 3 point to more low-level repetitions and fewer higher-level counterclaims.

Session 3: Case study Ben with Martin. Ben's partner for the third session was his lifelong friend "Martin". Like Ben, Martin infrequently participates in discussions during science class. However, Martin's tests and lab reports reveal a comparatively lower level of comprehension of the concepts learned in class. I anticipated their discussions would be short with frequent agreements, simple disagreements, or quick changes of stance for two reasons. First, because of their friendship, Ben would present a more flexible stance than he did with Annie to

prevent harming Martin's feelings. Second, Martin would likely accept or defer to Ben's ideas out of respect for his level of topic prior knowledge.

Upon reviewing the transcripts, Ben and Martin only averaged one speaking turn each per discussion question during their 3.4 minute third session. As the first excerpt below reveals, Martin was quick to accept and even adopt Ben's contribution to the point of repeating and rephrasing it. The discussion ended as their agreement removed the need for further contributions or clarification. The second excerpt supports my prediction that Ben would be more careful in the wording of his disagreement than he was with Annie. As Line 95 reveals, Ben softened his disagreement by first suggesting a partial agreement with Martin's claim before presenting a complete countering argument (TAP). Again, Martin agreed with Ben's argument – even though it countered his claim – and the discussion ended.

Table 25
Examples of collaborative and cajoling responses

Day 3 Line 92	Ben	Development could stop a lot of water from making it to the river. C2b The runoff could build up in the city and make a "boom"-like explosion into the river. D2b
93	Martin	I agree with Sam, C1b because the houses could block the streams and runoff, C1c and that could cause loss of runoff to the rivers. C2a
Line 94		*What are possible solutions to this action?*
95	Martin	One solution to reducing this runoff would be to not build houses there. C2b
96	Ben	That seems about right, C1b but the population keeps growing, D2b so you can't stop building houses, W2b but you don't have to build them there, C2b you can build them somewhere else. C2a
97	Martin	Yeah. C1b

In Sessions 1 and 2, Annie challenged Ben to elaborate on his position. These challenges fuelled additional arguments. In this session, neither Ben nor Martin

challenged one another to defend or elaborate on their contributions. As shown in both of the above excerpts, the discussions were either two contributions of the same opinion (Lines 92 and 93), or a slight elaboration of an opening assertion that was accepted without an expectation of an explanatory warrant (Lines 95 to 97). Consequently, the discussions lacked a need for continuation and so ended. Consequently, Ben's Session 3 coded transcripts revealed a dramatic drop in warrant usage (Session 1: 7 examples, Session 2: 10 examples, and Session 3: 1 example) and an inability to create TAP.

Martin's usage of argument features during Session 3, on the other hand, improved. I believe, along with classroom instruction and practice, Ben's linking of evidence to his claims during the session guided Martin's participation. The excerpt above (Lines 92 and 93) reveals how Martin's speaking turn mirrored Ben's opening turn of the session.

The results of Ben and Martin's Session 3 discussions confirmed my predictions. Ben presented a more flexible stance than he did with Annie, and Martin accepted or adopted Ben's ideas.

Session 1: Case study participants Caitlyn, Dana and Eric. Caitlyn, Dana and Eric were selected among the Grade 8 students participating in this study for their relatively lower usage frequencies of claims, data and warrants during the three sessions. Caitlyn's argument feature usage was lower than Annie and Ben's, but slightly above the class average. Dana, whose first session participation was lowest in the class, demonstrated a remarkable improvement during the second and third sessions. Eric's overall argument feature usage was the lowest in the class

(while meeting the selection criteria). Their belonging in the same discussion group was not a factor in being selected for this analysis.

Caitlyn, Dana and Eric's first recording session lasted 3.3 minutes (just over half the class average). Caitlyn initiated the discussions four out of six times and included supporting data and/or a warrant in all but her first speaking turn. She also combined argument features during most of her speaking turns by averaging 2.4 features per turn. Eric revealed the highest average number of features per turn in the group (3.4) by contributing 17 argument elements during 5 speaking turns. Dana limited her participation to a single speaking turn. These students selected the following three topics for discussion: Topic 9 ("Diversity of aquatic life forms"), Topic 3 ("The effect of ocean currents and winds on regional climates") and Topic 4 ("The effect of water and ice on surface features").

Caitlyn was especially motivated to work with the material in the Water Unit as it made several direct and indirect connections with her area of career interest – marine biology. Her participation during the recording sessions bore this out.

Caitlyn chose to open the session to discuss her purportedly most familiar topic (Topic 9: "Diversity of aquatic life forms") by correctly defining a food web. Neither Dana nor Eric challenged Caitlyn's lone claim – they likely agreed with her assertion and saw no need to add or counter it. In response to Caitlyn's second speaking turn (a complete display of TAP), however, Eric asserted a correct string of four counterclaims and one "D4b" piece of evidence (data based on an authoritative source). The following excerpt contains these speaking turns.

Table 26

Examples of countering claims

Day 1 Line 247	Caitlyn	I think humans are eating too many fish, C2b 'cause the bird population is going down, D2b because they don't have fish to eat. W2b
248	Eric	I disagree, somewhat. C1b I don't think we are eating too many fish, C1c I think we are eating too many large fish. C2a. We should eat more small fish to help the population of large fish, like salmon, go up. C4a I heard these facts on a radio broadcast. D4b

Caitlyn's combination of claim, data and warrant (a TAP display) within one speaking turn represented the degree of argument sophistication I was expecting my students to work towards with practice and instruction. However, as when Annie ended the discussions by contributing high-level evidence to support her claim regarding the importance of desalination technology for countries like Aruba, Eric's use of high-level evidence had the same effect; Caitlyn did not counter even though it disagreed with her argument. As a result, I feel an imbalance between Eric's and Caitlyn's topic familiarity was the main factor limiting the length of the discussions. The excerpt below further demonstrates their differences. While Caitlyn is able to consistently communicate the elements of argumentation into her speaking turns (a complete display of TAP), her evidence and explanation are either incorrect or less compelling.

Table 27
Example showing different levels of topic familiarity

Day 1 Line 251	Eric	I think ocean currents play a key role C2b because that it affects the whole life cycle of animals in the ocean. D2b
Line 252	Caitlyn	I don't think ocean currents play a very good role C2b because the ocean currents affect how an animal can travel D2b because some animals can't get through windy and lots of waves, W2b and boats can't get out so we can't get life sources like food for us. D2b
Line 253	Eric	Ocean currents aren't a major effect, C2b like storms aren't technically 100% ocean currents; D2b they could do with global warming, and increased heating, and pollution to the ozone

		layer. W2b

While a difference in topic familiarity was also the likely reason for Ben and Martin's short discussions. In those discussions, when Ben disagreed with Martin, Martin rephrased himself to agree with Ben's contributions. In the case of Caitlyn and Eric, even though Eric consistently disagreed with Caitlyn, Caitlyn made no attempt to persuade or elaborate on her contributions.

Dana's lack of participation during the first session is noteworthy as she did have the opportunity to join in on discussions she declared to be familiar with. I could find no evidence in the transcripts that either Caitlyn or Eric's assertions negatively influenced Dana's participation.

Caitlyn and Eric, even without argumentation training, demonstrated a similar ability to link together data – and occasionally warrants – to support their claims. Interestingly, Eric's two displays of TAP and consistently sound evidence were confined to topics purportedly familiar to him. Caitlyn, however, demonstrated an ability to make TAP displays even when the quality of her evidence revealed limited knowledge of what is purportedly a familiar topic. Consequently, Eric's participation appears contingent upon his topic knowledge, while Caitlyn's participation is not.

Surprisingly, the existence of oppositional arguments did not have the same effect of extending the discussions as it did during Annie and Ben's sessions. Consequently, I think it would have been necessary for this group to challenge each other on their claims and the quality of their evidence in order for the discussions to contain more than two or three speaking turns.

Session 2: Case studies Caitlyn, Dana and Eric with Jenny. The second recording session saw the addition of a new member named, "Jenny" (described below). This session was 2.5 times longer than Caitlyn, Dana and Eric's first session. Note, the group covered the same number of topics (three) in each session, and I provided them with the same amount of time to carry out their discussions. No other discussion group in the science class demonstrated a similar jump in session length.

The three topics covered by these students during the second session were as follows. Topic 2: "Properties of salt water and fresh water", Topic 1: "Sources of fresh water", and Topic 8: "Productivity and species distribution in aquatic environments", respectively. The group claimed to have weak familiarity with two-thirds of the topics. Consequently, I expected the student's data to be of limited validity. Recognizing this, I was interested in noting whether the students would be able to apply the argumentation instruction and make displays of the Toulmin Argument Pattern during the session using the scaffold if they truly had limited topic knowledge.

Jenny is a candid, hard working, goal-oriented student who shares similar academic success with Annie and Caitlyn. In class, Jenny is the most vocal and articulate student in grade 8 science. She carries strong opinions, and has demonstrated in research presentations a desire and ability to back up her ideas with supporting data. Not surprisingly, compared with the entire class, Jenny had the third highest speaking turn frequency averaged over the three recording sessions, and the highest in this second session. Jenny's ranking of the Session 2

topics were as follows: Topic 2: 2nd, Topic 1: 1st, and Topic 8: 9th. Another piece of evidence that alerted me to Jenny's possible influence over the group came from recalling the topic of her science research project: "Bottled Water".

Among this group of four, Eric was the only student to contribute fewer elements during the second session; he contributed 14 argument elements during 7 speaking turns as compared to 17 argument elements during 5 speaking turns during the first session. I predicted Eric's contributions to the discussions would have been proportionately greater in Session 2 given his demonstrated familiarity (sound data usage) with the topics and ability to link claims, data and warrants during Session 1. Conversely, Caitlyn contributed 37 elements during 18 speaking turns (nearly double the elements made in Session 1) and Dana contributed 18 elements during 13 speaking turns (9x more elements than in Session 1). Dana was the only student whose number and frequency of elements improved proportionately beyond the increased length of the session.

To direct my analysis of this group's usage of the elements of argumentation, I remained focused on answering the following questions:

- Were oppositional or collaborative arguments more influential in extending discussions?
- Did the students make comparatively more arguments while discussing topics purportedly to be familiar to them?
- Did any of the students challenge members of their group to participate in the discussion or elaborate on their position?

The excerpt below, which came from the start of the group's discussion of the first topic, is a good representation of the session's oppositional and collaborative arguments. Caitlyn's response to Jenny's counterclaims represented a significant improvement over her Session 1 performance in that it was the first time she defended her position with countering evidence (Line 251). Further contributing to the increased length of this topic discussion were Dana and Eric's contributions. Dana's initial pair of claims countered Jenny's argument and supported Caitlyn (Line 253), while Eric's claim countered Dana's claim (Line 254) and supported Jenny's argument. After Caitlyn defended her own position, she did not re-enter the discussion. Meanwhile, Dana clung to her oppositional stance on Jenny's reasoning and continued to obstinately counter her three additional times with Level 1 (rephrased) claims and data. In contrast to the oppositional nature of Dana's contributions, and the supportive nature of Eric's first claim, Jenny demonstrated an ability to make both opposing and supporting arguments to scaffold her position. This quality of Jenny's contributions, plus her apparent enthusiasm for the topic appears to have motivated Caitlyn and Dana to affirm or elaborate their opinions.

Table 28
Example of an emotive discussion

Day 2 Line 249	Caitlyn	I think fresh water is so vital for humans and other forms of land animals, C2b because we need fresh water to drink every morning, D2b and if our bodies didn't have enough fresh water, we could die because our bodies would get dehydrated. W2b
250	Jenny	Yes, I know, C1b but we can turn fresh water into salt water with a filter. C2b
251	Caitlyn	Yeah, C1b but still some animals can't drink salt water. D2b Animals don't know how to filter it. D2b
252	Jenny	Exactly, exactly. C1b So we should leave all of the fresh water for animals, and we use salt water and clean it. W2b Then there would be way more water for the animals. W2a

253	Dana	But some people can't afford to desalinate it, C2b and they can't go to a stream to get fresh water. C2a
254	Eric	It would be paid for by the government. C2b
255	Jenny	I agree with Cole. C1b I think it should be paid for by the government. C1c
256	Dana	Maybe the government can't afford it. C1b
257	Jenny	The government needs to afford it. C1b
258	Dana	Well the government sometimes can't; C1d the people take the money and don't do that… D2b
259	Jenny	Do you know how much the government pays their workers? They could easily if they cut back on how much they pay their workers. D2b They could easily pay for a water filter. D1d
260	Eric	Oh, cut back on funds of BC workers, that's… D1d
261	Dana	Yeah. D1b

Topic unfamiliarity may have contributed to Eric's drop in element usage frequency and TAP usage in the remaining two-thirds of the session. He claimed on his pre-discussion prior-knowledge self-assessment that these topics (Topics 1 and 8) were least familiar out of the nine topics in the unit (Ranked 9th and 8th, respectively). Eric's Session 2 contributions lie in sharp contrast to his element usage during the first session while discussing his purportedly most familiar topics (Topics 3 and 4). During that time – even prior to argumentation instruction – he contributed an average of three elements per turn and showed an ability to create TAP. The accuracy of Eric's evidence in Session 2, however, remained strong. As his two speaking turns during the discussion on desalination suggests, Eric chose to contribute to a discussion when he had a valid contribution:

Table 29
Examples of participation with and without topic familiarity

Day 2 Line 269	Eric	Yeah, D1b but you need lots of energy; C2b you need to take out everything in the water to make it; D2b and you also take out all of the vitamins. D2a
270	Caitlyn	Yeah, yes, I agree with Cole, D1b because some animals need those vitamins in the water to survive. D2b
273	Eric	It is possible, C1b but it would also be very hard and costly, D1d but it would also be more useful to spend more money on

		reviving our fresh water, C2b or not using all of the fresh water we already have. C2b
274	Caitlyn	I don't think so, C1b because it would be too costly. D1c

Caitlyn, as shown in her Session 1 contributions (and in the two turns shown above) actively participated in the discussions even if she had nothing new to contribute. Caitlyn's purportedly low prior-knowledge did not point to a weakness in her ability to make a TAP display to solidify her position. In fact, she contributed as many argument elements per speaking turn as Jenny. In this session, unlike the first session, however, Caitlyn responded to the pressure of oppositional fact-based assertions focused squarely at her by contributing backings and qualifiers to reinforce her position – perhaps while using the argument scaffold for guidance. Furthermore, she constructed TAP displays despite being unable to incorporate the same level of supporting data as Jenny and Dana. That is, while she demonstrated a usage of TAP, the detail embedded into those arguments was based on either her own every day experiences (Lines 286 and 290) or borrowed from the more technical evidence contained in her fellow members' arguments (Lines 270 and 274). Despite Caitlyn's consistent usage of multiple elements per turn, she ultimately accepted the evidence of her fellow group member's position (Line 309).

Table 30

Example of steadfastness and then ultimate acceptance

Day 2 Line 286	Caitlyn	Yes, I do drink bottled water, C3b and I think it would be a good thing to drink bottled water, because you can travel. D3b If you are travelling somewhere, you can't bring, like, fresh water with you. W3b
290	Caitlyn	Sometimes it's easier to buy a bottle of water for a dollar than go out and buy a refillable water bottle. D2b It's like five or ten dollars for a good water bottle, W2b why don't you just buy a dollar plastic one?
309	Caitlyn	Okay you guys. I am going to have to agree with you, though.

		D1b I think that I should go out today and buy myself a water bottle, a stainless steel, not a plastic anymore. W3b

In the other case study discussion group analysis (with Annie, Ben and Michael) I presented evidence that showed when Annie openly challenged members in her group to participate or clarify their position, they responded with relevant arguments. With regard to the grouping of: Caitlyn, Eric, Dana and Jenny, Dana challenged both Jenny and Caitlyn twice to elaborate. As the following example reveals, Dana's challenges worked to extend the Topic 2 discussion.

Table 31

Examples of challenges for elaboration

Day 2 Line 264	Jenny	Definitely! We're definitely able to do that. C2b I mean, all we need is a filter and boil it. D2b Then it's clean and we can drink it. W2b
265	Dana	And where are we supposed to get the filter? D2b
266	Jenny	The government! C2b
267	Dana	How do you make it?
268	Jenny	The filter? It's made by, like, factory workers. D2a

Session 3: Case studies Caitlyn and Dana with Roland. Caitlyn and Dana's group for the third session did not include Eric or Jenny. A diligent student named "Roland" took their place. The session lasted 3.4 minutes, much shorter than Session 2, and similar in length to Caitlyn, Dana and Eric's first session. Neither of the girls ranked Topic 5 highly (both girls assigned a rank of 6th), while Roland claimed some familiarity by assigning it a rank of 4th. However, since the students received the relevant classroom instruction on the Water Unit, the prior-knowledge rankings were somewhat less of a factor in the third session (by my records none of the students missed any instructional time).

Roland is a bright and thoughtful student. He contributes regularly to class discussions, completes the assigned work to a very good standard and works to score well on his assignments and tests. During the previous two sessions, Roland

worked with one other student, "Keegan" – a close friend. They worked quickly yet diligently through the discussion questions I prepared for them. Unfortunately, their speaking turns were brief and lacked counterclaims; with only two exceptions they agreed with whomever made the first assertion, and then moved on. Further, as a result of covering such a large percentage of the discussion questions during the first session, Roland and Keegan completed the remaining material during the second session in just 2.5 minutes – leaving them with little opportunity to practice the argumentation skills they had just been taught, and use the argument scaffold they had been given.

To direct my analysis, I applied the same three focus questions to the Session 3 transcripts as I did during Sessions 1 and 2:

- Were oppositional or collaborative arguments more influential in extending discussions?
- Did the students make comparatively more arguments while discussing topics purported to be familiar to them?
- Did any of the students challenge members of their group to participate in the discussion or elaborate on their position?

Caitlyn's transcripts revealed an application of the key vocabulary and concepts introduced and discussed during the Earth Science lessons. As noted in my observations of Session 2, Caitlyn was able to construct arguments in an attempt to hold onto her views against an enthusiastically oppositional group member. However, those arguments did not include detailed knowledge of the topics; her evidence was limited to her life experience and neglected to include the relevant

vocabulary or scientifically reliable evidence (especially while discussing topics she purported to have little prior knowledge). During the Session 3, however, Caitlyn was able to combine the concepts and vocabulary she had learned in class with the three elements of argumentation.

The influence of oppositional arguments on the length of the discussions and the sophistication of the arguments was evident again in this session. Dana's firm stance and incorporation of data (albeit limited) seemed to fuel Caitlyn and Roland's arguments. They both provided evidence and warrants to back up their countering claims in an apparent attempt to sway her position regarding the consequences of removing vegetation on a slope for residential development.

In their efforts to convince Dana to accept their evidence, both Caitlyn and Roland displayed their highest number of warrants and combined argument elements per turn during Session 3 (2.4 and 2.0 elements per turn, respectively) even without access to the argument scaffold. Despite the usage of warrants in her arguments, Caitlyn made the only complete TAP display within one speaking turn during the session. A possible explanation for her – and the other members in the group – inability to put together a complete TAP could be the absence of the argument scaffold. My analysis of the transcripts, however, revealed a second possible explanation: a lack of claims. This group collectively made only 11 claims during the session while contributing 19 data and 11 warrants. Compared to the class totals: 214 claims, 171 data and 64 warrants for Session 3, this group's claim usage is lower. This led me to perhaps the most significant piece of evidence pointing to Dana's influence during the discussions. She made the majority of the

claims (6 out of 11). As the following excerpt reveals, Caitlyn and Roland responded to Dana's provocative claims, counterclaims and evidence (Lines 292, 294 and 303) with predominately countering evidence and explanatory warrants.

Table 32
Examples of provocative elements

Day 3 Line 290	Caitlyn	So, if a group of houses was built on a bank, a landslide could occur, C2b because a lot of water could get saturated into the ground. D2b
291	Roland	The landslide would take out all of the houses, C2a so there would have been no point in building there in the first place. W2b
292	Dana	I disagree, C1b because of the great views. D2b
293	Roland	There are great views along a river? D1b It is like a little strip of water. D2b You would have a view of the house across the river. W2b
294	Dana	Yes, C1b but you can go swimming in the river. D2b
295	Caitlyn	But would you like your house to be destroyed by a landslide? D2b
296	Dana	I could put barriers along the property. D2b
297	Roland	The landslide would be so heavy that you couldn't control it with a fence. D2b
298	Dana	Not a fence, a barrier. D2a
299	Roland	I think a barrier wouldn't help either, D1b because the landslide would just shift the barrier. D2a
303	Dana	If we remove the bushes, you would probably have a better view of the mountains in the background. C2b
304	Ryan	The bushes are probably not even half your size. D2b They wouldn't affect your view anyway. W2b
305	Caitlyn	The trees and bushes are protecting your house. D2b If they are removed, the rainwater runoff coming down from the mountain is going to end up in your house. W2b

As noted previously, the presence of arguments that challenged a student to explain or elaborate their opinions served to get detailed responses. Caitlyn and Roland openly challenged Dana to clarify elaborate on her opinions once each during the session. Dana responded to challenges by providing either a single counterclaim or refuting piece of evidence – not a detailed response. So, in this

group, challenges or requests for elaboration did result in the contribution of additional – though brief – evidence.

Dana's participation in Session 3 was significantly greater than her participation during either Sessions 1 or 2. She, however, did not apply topic knowledge, or show any improvement in linking the argument elements into a display of TAP. Since her selection for the case study was to analyze her demonstrated growth in participation during the sessions, the results are informative. Her overall increase in usage frequency of the elements of argumentation during the sessions was not an indicator of her ability to apply topic knowledge or argumentation instruction. It instead may have been simply the result of a desire to influence the responses of her group members.

In recognizing the group's short session duration, I looked to find an explanation. At first, I thought Caitlyn and Roland opted to end the discussion early out of frustration over Dana's unwavering position. However, upon comparing this group's responses to the discussion prompting questions with the rest of the class, I noted a discrepancy in the material they covered. Caitlyn, Dana and Roland neglected to discuss possible solutions to each of the land development proposals – as requested in the handout I provided. Consequently, this group completed only one-half of what I expected from them.

Session 3: Eric with Jenny and Leonard. For the third session Eric joined a new group. The other members were Jenny (whom I described in detail above) and Leonard (a "B" student with good comprehension and articulation skills in class, who unfortunately struggles with organization and deadlines). The length of their

recording session (5.4 minutes) was precisely two minutes longer than Caitlyn and Dana's group, and longer than the class average (4.65 minutes). Aside from length, my analysis of this series of discussions contained notable similarities and differences from Caitlyn, Dana and Roland's third session.

Throughout the majority of the discussions during Session 3 the students' arguments were oppositional. The first disagreement came as a result of Leonard making a TAP display that prompted Jenny and Eric to counter (Line 261, below). Their countering arguments, as revealed in the excerpt below, still retained the concept knowledge and the collaborative element displayed earlier in the session. The end result of Eric and Jenny's collaborative effort to construct an oppositional argument to sway Leonard's opinion led to a comparatively higher number of argument elements per speaking turn than during the first part of the session, giving additional credence to the claim that oppositional arguments lead to extended discussions.

Table 33
Example of collaboration to sway opinion

Day 3 Line 261	Leonard	I think removing the bushes from one side of the river would be good, C2c because it would move the animals to the other side of the river, D2c so that could be all human stuff on the other side of the river, and the other side of the river could be natural. W2c
262	Jenny	Yeah, C1b but it depends what kind of bush it is. C2b What happens if it is an endangered bush? D2b
263	Leonard	You could take the bush and move it over to the other side of the river. D2b
264	Jenny	That's so weird. D1b
265	Leonard	Well, if you have the roots, you can just put them back into the ground. W2b
266	Jenny	I don't think so, W1b because you would rip the roots out of the ground. W2a
267	Eric	Well Leonard, it is always good to leave things in their natural

		habitat where they are growing. C2b

As with Dana in the other Session 3 group, and Caitlyn during Session 2, Leonard demonstrated a determination to maintain his original opinion despite the countering evidence of his group members. However, Leonard did not adjust his opinions. His contributions to the discussions in Session 3 were, therefore, more similar to Dana and her steadfast refusal to adjust her opinions. Eric and Jenny, however, responded differently to their obstinate group member than Caitlyn and Roland did with Dana. Eric, Jenny and Leonard made 28 claims, 18 data and 12 warrants. Their relative usage of the argumentation elements (in particular claims) more closely matched the class' overall relative usage. Consequently, Eric, Jenny and Leonard made a higher number of TAP displays in one speaking turn (four). While this represents a decrease over their Session 2 TAP usage with the argument scaffold, it is greater than what Caitlyn, Roland and Dana's group displayed – albeit during a short recording session. It would be speculation to point to a definitive cause for the differences in claim usage between the two groups; however, the provocative nature of Dana's arguments may have elevated, to a comparatively higher level, the emotions of her group members to forget about applying the learned Toulmin Argument Pattern.

Chapter 6 – Summary of the results

The 25 Grade 8 science students demonstrated a progressive overall increase in using each of the three elements of argumentation (claims, data, and warrants) during the three recording sessions. However, that investigation did not examine the interactions between the students in the discussion groups; it didn't consider the students' prior knowledge or the quality (accuracy) of their assertions; and it didn't attempt to uncover how the groups' interactions influenced the length of the discussions and the usage of the Toulmin Argument Pattern (TAP). Consequently, I devised the criterion to select five students to acquire this information.

My case study analysis of Annie, Ben, Caitlyn, Dana and Eric added both confirmation and some uncertainty to these three claims:

1. Prior topic familiarity influences discussion participation
2. Discussions containing oppositional assertions and/or invitations to participate were comparatively longer than discussions containing predominately collaborative assertions
3. Argumentation instruction and the use of a scaffold during discussions leads to more displays of TAP

Prior topic knowledge influences discussion participation

Annie and Ben consistently contributed among the most argument elements during the three sessions (Hence their selection for the case study as "Student A" and "Student B"). I was surprised, however, by their ability to increase the number of speaking turns and elements during the second session, given they both discussed

their two most familiar topics during the first session. Seeing their progress led me to analyze the quality or validity of all of the case study students' claims and the evidence they were contributing. I suspected the higher number of argument elements would contain evidence of low validity. These five case study participants, however, made very few examples of inaccurate arguments. Most commonly, the students, when the original evidence was beyond their level of topic knowledge, applied the ideas and assertions of a group member to scaffold their own arguments. In some cases, as demonstrated by Eric, the decision to refrain from contributing to a discussion may have been due to a limited familiarity with the topic.

Session 3 showcased the students' abilities to apply their newly learned Earth Science concept knowledge and additional argumentation training, but without the use of an argument scaffold. Four out of the five case study students demonstrated a similar improvement in their argumentation element usage frequencies. This improvement mirrored the pattern of the overall class average. Caitlyn, in particular, incorporated more concept specific vocabulary and knowledge into her arguments than in the previous sessions.

Despite this improvement, the number of TAP displays made within one speaking turn by the five students did decrease compared to the number of Session 2 TAP displays. The absence of the scaffold to guide the students towards incorporating the three argument elements is a possible explanation for this trend.

Oppositional assertions and invitations to participate influence discussions

Every discussion that drew opposing opinions from one or more of the group members were longer in duration than discussions that contained predominately collaborative or accepted opinions. In addition to longer durations, the discussions containing opposing points of view contained more examples (and higher level examples) of claims, data and warrants. Furthermore, with the exception of Dana's obstinate behaviour during Session 3, the students displayed more TAP displays.

The discussions containing collaborative argumentation were comparatively shorter. The only exception to this was with Annie's group during Session 3. During those discussions Annie was much more apt to collaborate and build consensus if her group appeared to disagree with her opinions. While the session was longer than the class average, the number of elements included in each of the speaking turns – and the number of TAP displays – was lower than during Annie's previous sessions. Ben showed similar concessions as Annie during his third session discussions. He also was much more likely to agree or accept his group member's (Martin's) arguments. Ben's discussions matched those of other groups that used primarily collaborative or supportive claims or evidence. That is, the collaborative discussions were shorter than oppositional discussions and they contained features that were predominately low-level repetitions of an earlier claim.

Discussions that included invitations or challenges to contribute or elaborate on an earlier opinion similarly lengthened discussions. While invitations or challenges were evident in many of the groups' discussions, none of the other five students in the case study challenged their fellow group members in the manner and frequency that Annie did during the first two sessions.

Argumentation instruction and the use of a scaffold influences TAP displays

Three of the five case study participants (Annie, Ben and Dana) mirrored the science class' improved element usage frequencies during the second session. Caitlyn contributed more elements during Sessions 2, but as a frequency the number was slightly less. The students' overall ability to increase their number of speaking turns, argument usage frequencies and TAP displays during the second session indicated the argumentation instruction preceding the session and the argument scaffold used during the session were efficacious.

Upon noting the increases, I questioned the quality or validity of the claims and evidence the students were contributing. I suspected the higher number of argument elements would contain evidence of low validity. These five case study participants, however, made very few examples of glaringly inaccurate arguments. Most commonly, the students applied the ideas and elements of a group member to scaffold their own arguments when original evidence was beyond their level of topic knowledge.

The slight drop in the number of TAP displays within one speaking turn (down from 8 to 5) during Session 3 provided some evidence supporting the effectiveness of the argument scaffold during Session 2. Four out of the five students in the case study made progressively more frequent usage of the three argument elements – including warrants – during the study period. Only one of those students (Annie) made more displays of TAP during Session 3, and only one student (Eric) made more TAPs during Session 1. However, given the small number of TAP

displays within one speaking turn, definitively attributing the students' TAP usage to the scaffold is not possible.

As the results of this study indicate, the students' prior knowledge and argument training did positively influence their ability to contribute arguments using the elements: claim, data and warrant. My analysis of the students in the case study, however, revealed the interactions within the small groups also played a significant role. Namely: the nature of the arguments (oppositional versus collaborative) and the presence of invitations or challenges to participate or elaborate. Although not a focus of this study, the effect of topic interest and motivation may have also played an important role in the students' ability to construct arguments using Toulmin's elements of argumentation.

Chapter 7 – Pedagogical Implications

This study has implications for the teaching and learning of argumentation in middle school science classrooms. The results add to the literature on what we know about the importance of topic selection, the arrangement of discussion groups, the creation of coding rubrics and the allowance for numerous discussion opportunities.

Appropriate topic selection was an essential contributor to the length and sophistication (TAP usage) of the discussions. I recommend, especially prior to concept instruction, the students are able to select socioscientific discussion topics that make connections with their prior knowledge, life experiences and personal interests. These topics are also more likely to draw countering points of view, which are essential to the introduction of new claims, evidence and warrants into the discussions. Consequently, socioscientific topics are an essential part of providing students with practice opportunities using the Toulmin Argument Pattern.

The wording teachers choose when writing discussion prompting questions plays a significant role in encouraging students to draw upon their personal experiences. As I noted in the analysis, the students were better able to incorporate personal experiences into their arguments when the questions explicitly asked them to reflect on situations and current events happening in their communities. For example, instead of asking the students to discuss the effect of deforestation on run-off and soil erosion, present to them – or learn from them – actual occurrences of the processes presently happening at locations near to them. The resulting discussions

are more likely to be dialogical than declarative in nature.

A fascinating outcome of this study was gaining a better understanding of group dynamics and how they influence participation during oral discussions. I observed that the interactions of the group could both impede and enhance the number and combination of elements used in the arguments, the level of enthusiasm, and the length of discussions. Predicting the performance of a group remains difficult, however, members who are friends are more likely to agree and less likely to present a countering argument, add additional evidence, or include supporting warrants. Consequently, if a teacher's objective is to carry out a collaborative activity, groups composed of student-friendships may be superior. However, if the students are assigned a discussion task that is inquiry driven, grouping criteria based more heavily on collegiality than on friendships appear to promote more sophisticated and longer arguments.

Through this study, I also gained a better understanding of a preferred size for small-group oral discussions. Groups of three are desirable. In groups of two, there was a greater likelihood for agreement, and consequently, shorter discussions with fewer elements used. In groups of four or greater, on the other hand, one or more of the participants often removed themselves from actively participating in the discussion. Perhaps the impression was their absence wouldn't be noticed.

Teachers may also significantly shorten the length of the students' discussions inadvertently when they interject and contribute. I noted this while coding the first recording session transcripts weeks after it took place. At the time, the objective behind my interjection was to challenge the group to consider a piece

of related evidence – that made a reference to authority. I learned, through the recorded transcripts, the students were unable to continue with that discussion topic. The reason, I now realize, was that claims and evidence containing a reference of authority (or presented by a person of authority) may leave the discussion participants unable to respond at a similar level and so they may be left unable to continue contributing further to the discussion.

The creation of a coding rubric that adapted the Toulmin Argumentation Pattern framework was a contribution to the literature. The rubric objectively recognized the content of students' claims, data and warrants at four sublevels of sophistication. With this rubric teachers are able to track not only developments in the student's opinions, knowledge and understanding of science concepts, but also improvements in their skill at using and combining the elements of argumentation. Consequently, this rubric enabled the measurement of a students' scientific literacy with respect to the topics being discussed.

Finally, I have a better appreciation of the importance of providing an argumentation scaffold to the students while they are gaining familiarity of the pattern required for building powerful oral arguments. I have always used scaffolds in other aspects of student support, such as: report writing, project design and concept summarizations. However, with the high frequency of its usage during oral discussions, the scaffold was more than a guide; it was a crutch that could be cast off once the students' gained sufficient confidence in using the Toulmin Argument Pattern.

Looking ahead, my approach to science instruction as a result of this study is more conscious of my students' needs for time, practice and instruction. I, therefore, recommend teachers include a variety of topics during discussions that cater to their students' varied background knowledge, experiences and surroundings. Finally, while choosing topics that are relevant to the students, their community and the curriculum, teacher can create scientific literacy through argumentation by including questions that draw opposing points of view. Enabling these things to occur, I am confident students can increase their usage of the elements of argumentation in all aspects of their oral and written science work, ultimately without the need of a scaffold.

It is clear that scientific literacy is a necessary part of science instruction in all grades of school. For scientists, argumentation is a vehicle for communicating and challenging their findings; therefore, argumentation instruction serves to promote scientific literacy and is a relevant basis for this study.

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