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Korean Middle School Students' Epistemic Ideas of Claim, Data, Evidence, and Argument When Evaluating and Critiquing Arguments

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ABSTRACT

An enhanced understanding of the nature of scientific knowledge—what counts as a scientific argument and how scientists justify their claims with evidence—has been central in Korean science instruction. However, despite its importance, scholars are generally concerned about the difficulty of both addressing and improving students' epistemic understanding, especially for students of a young age. This study investigated Korean middle school students' epistemic ideas about claim, data, evidence, and argument when they engage in reading both text-based and data-inscription arguments. Compared to previous studies, Korean middle school students show a sophisticated understanding of the role of claim and evidence. Yet, these students think that there is only a single way of interpreting data. When comparing students' ideas from text-based and data-inscription arguments, the majority of Korean students barely perceive text description as evidence and recognize only measured data as evidence.

Ⅰ. Introduction

The epistemic understanding of science—what counts as scientific knowledge and how scientists come to know and warrant their ideas—has been recognized as critical to promote science literacy (Archive, 2012; Duschl, 2008). However, despite its importance, scholars are generally concerned about the difficulty of both addressing and improving students' epistemic understanding, especially for students of a young age. Questionnaires developed to assess students' understanding of the professional nature of science (NOS) could be too abstract and thus difficult for the level of elementary and middle school students to understand (Sandoval, 2005). Consequently, these questions elicit only ambiguous ideas, often expressed with very short, unclear answers, making it difficult to make a reliable and useful interpretation. Often students simply answered, "I have no idea." In addition, since these questionnaires hardly situate students in relevant contexts, it could be the case that students rarely reflect and think deeply about these questions and may consider them to be tests evaluating content knowledge. If we want to understand students' ideas and thinking about evidence, it would be best to ask questions, such as "what do you think evidence is?", in situations where they look for or evaluate evidence during their science activities and tasks. Situating students in relevant tasks also allows them to use their epistemic resources, drawn from both their everyday experience and experience with science (Moje, 2007, 2010; McNeill, 2011).

Alternatively, students' epistemic ideas are increasingly addressed in the context of argumentation practice, as this would offer students richer opportunities to reflect on epistemic ideas, such as what can be counted as claim, data, evidence, and argument. In Korea, while there have been growing studies regarding scientific argumentation, little research has been concerned with the connection between student argumentation practice and the epistemic understanding of science (for review, Shin & Choi, 2014). In this context, this study examined Korean middle school students' epistemic ideas when they engage in the evaluation and critique of data-based and text-based arguments. When students are asked to analyze, evaluate, and critique arguments, they cannot but reflect on their epistemic ideas. For instance, students describe their ideas regarding different kinds of claims, evaluate whether they were based on the prediction of observed phenomena or on simple inference, and generate their own epistemic criteria to compare two arguments (Ryu & Sandoval, 2012, Moje, 2007; Textual Tools Study Group, 2006). In particular, this study documented and compared students' epistemic ideas and criteria when they engaged in reading text-based versus data-inscription arguments, as the

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genre-specific structure of argument texts and the characteristics of data representation seem to affect the ways in which students identify and make epistemic decisions. For example, students seem to ignore the description of data (texts) as evidence (Sandoval & Millwood, 2005). Methodologically, the study draws on the notion of practical epistemology (Sandoval, 2005), which suggests that epistemic reflection on practices could be best captured through interviews where students participate in knowledge construction or evaluation practices.

This study investigated middle school students' ideas about claim, data, evidence, and justification by conducting multiple clinical cognitive interviews that were situated in relevant reading arguments tasks. By looking at the epistemic understanding of these terms, the study focused on addressing students' ideas of the meaning, role, and relationship of these terms. Two research questions guided this study: 1) What are middle school students' ideas about claim, data, and evidence in the context of text-based and data-inscription arguments? and 2) How does the genre-specific text structure and the characteristics of data-inscriptions affect students' epistemic decisions?

II. Background

1. Student Epistemic Ideas of Professional Science

A review of the long-running enterprise of research into students (and teachers') conceptions of NOS (Lederman, 2007) show it to be a strictly empirical effort. It has been an attempt to document students' views about science, primarily to assess their alignment with ideal views, often called informed views. However, compared to the long history of NOS research, relatively little work as aimed to understand students' ideas about science and its practice and how such ideas might develop (Sandoval, 2005).

Driver and her colleagues (Driver *et al*., 1996) and Carey and Smith (1993) examined students' epistemic beliefs. Both of these schemes argue that students progress through three levels of epistemological sophistication, with few achieving the highest level. While these two frameworks were developed independently, they are strikingly similar both in the number of levels they propose and the character of each level. The lowest level was named by Driver as phenomenon-based and is characterized by a view that science is the discovery or observation of phenomena in a way that leads to the accrual of facts about the world. Experiments "give you the answer" directly (Carey *et al*. 1989), and there is no sense that scientists generate or construct ideas and test them. The second level is characterized by the idea that experiments test ideas: that is, a scientist generates an idea about something and does an experiment to see if they are right or wrong. Driver and colleagues term this view relation-based to connote a simple view of relations between variables. As discussed by Carey and Smith, this level entails a view that theories are just hypotheses that have been proven, rather than being explanatory frameworks that can generate specific hypotheses and predictions. Also, at this level there is no sense that experiment and observation are theory-laden, or that science is a social enterprise including an element of persuasion. Finally the third level in Driver's scheme is model-based reasoning, and includes a notion that scientists build models and theories as explanatory frameworks, that empirical work can provide partial evidence for or against a model but a large number of experiments may be needed to lend a model credibility. Driver and colleagues did not claim this third level was a developmental endpoint, but Carey and Smith argue that their third level is one. Their description extends the Driver notion to include an explicit commitment to the complex social nature of science, especially the roles of funding and other institutions on what science gets done, how claims are tested and ratified.

Carey and Smith's argument that their "level 3" epistemology is a developmental endpoint is a crucial difference from Driver and colleagues. The Driver framework emerged from their empirical analysis. While the Carey and Smith framework is also partially emergent, their level 3 definition is derived a priori, from their interpretation of philosophical, historical, and sociological studies of science (Carey & Smith, 1993). Most importantly for the present study, while Driver and colleagues actually saw some students who could be classified as model-based, in none of their work have Carey, Smith, and colleagues seen evidence of a level 3 epistemology (Carey *et al*., 1989; Smith *et al*., 2000; Smith & Wenk, 2006). They have found evidence of students apparently moving toward level 3, whom they assign a "level 2.5." Children at this level exhibit a nascent awareness of the overarching scope of theories as frameworks, or an acknowledgment of science as social. This study draws on Carey and Smith's framework and their Nature of Science Interview (NSI) protocol to find out middle school students' epistemic ideas and the level of epistemic understanding.

An explicit assumption of Carey and Smith, and a tacit one by Driver and colleagues, is that these distinct epistemological levels represent consistent, coherent worldviews. Yet, there is evidence from Driver and colleagues' own data (Leach *et al*., 2000) and studies using the NSI (Sandoval & Morrison, 2003), that this assumption is unwarranted. Instead, there is a growing body of evidence on students' epistemological ideas against this coherence assumption (Hammer & Elby, 2002; Louca *et al*., 2004; Sandoval, 2005),which calls for more examination of students' epistemic ideas situated in relevant activities and practices.

2. Addressing Epistemic Ideas in Reading Scientific Arguments

One goal of learning to scientifically argue is to promote scientific literacy that prepares students to be informed and responsible citizens in a democratic society. While lay people might hardly engage in writing about a scientific issue, they commonly engage in reading science-related texts in this digital media era. Based on their reading, people develop understanding, raise questions or issues, and determine where they stand on the issues in everyday lives. Thus, it is likely that students develop and reflect their epistemic ideas when they engage in reading scientific (or socioscientific) arguments. However, little research has been conducted in the context of reading argument. The reason for this is in part because most work of students' scientific argument has been focused on students' construction of arguments, and there has been little work on the evaluation or critique of arguments that assess students' ability to comprehend, interpret, and evaluate arguments (Osborne *et al*., 2012).

Students seemed to be able to develop an understanding for the importance of coordination of claims and evidence, identify the adequacy and relevance of evidence, and understand the genre-specific nature of text structure when they were asked to read arguments, and analyze, evaluate and critique them (Moje, 2010; Sutherland, 2008). These potentials are found in a range of research that integrates literacy and science (Pearson *et al*. 2010). Although these works hardly use the exact terms "epistemic or rhetorical quality" of scientific argumentation, their findings suggest that engaging students in reading argumentation can significantly support their improvement of the epistemic and rhetorical aspects of scientific argumentation. For example, when students compare scientific and lay-audience texts, they develop an understanding of different kinds of claims, whether based on the prediction of observational phenomena or based on simple inference (Moje *et al*., 2004; Textual Tools Study Group, 2006a). They also evaluate how evident the presented data are in relation to the claims, and thus whether the argument is rhetorically appropriate (Textual Tools Study Group, 2006a). Consequently, we not only visit articles published in the area of science education, but also extend our review to literacy literature—in particular, disciplinary-oriented literature.

1) Adapted primary literature (APL): understanding the role of claim and evidence

Adapted Primary Literature (APL) suggests how reading scientific arguments—especially through the format of professional science articles—could help students improve their epistemic and rhetorical understanding of scientific arguments. The scholars using this approach in the classroom particularly highlight the advantage of presenting a current theory (a scientific argument) to students, as opposed to presenting an argument as static facts in the science textbooks. The APL approach uses science research articles for science class. Considering students' content knowledge levels and reading comprehension levels, the professional journal articles are modified and adapted to enable students to adequately read and comprehend the articles in relation to the content area taught. Compared to science textbooks, the adapted professional articles maintain the canonical structure of the research article (research question, background, method, results, discussion, and future direction). These articles also provide more basic background knowledge in the front of the paper and describe the methods in much more specific detail. Results and discussion are presented in a manner in which scientists precede their results in an authentic way with promises and limitations, rather than presenting them as mere facts.

Baram-Tsabari and Yarden (2005) found that students were more likely to raise scientific criticism regarding the coordination between theory and evidence compared to when students were asked to read a popular science magazine. They argue that this seems to occur because students understand through reading these APL resources that scientists include argumentation as a means of presenting and weighing evidence and assessing alternatives, and thus they come to better understand the attitudes of uncertainty for both the techniques and results of scientific inquiry, which are subject to continual changes and reexamination. Falk and Yarden (2009) provided similar results, showing that students better understand the nature of coordination in science when using APL as opposed to science textbooks. Students showed enhanced understanding of new knowledge building; that conclusions should cohere with reading of evidence, even when data show some conflicts; and that scientific modeling and theory should satisfy high scientific standards. For the rhetorical perspective, students not only better understood that interpretation of texts and evaluation of concepts' potential are dependent upon the ways in which scientists present their argumentation, they also understood that a central communicative feature of primary literacy in science is the use of multiple representations including graphical representations to display the results from experiments more effectively (Hapgood *et al*. 2004).

Despite these promising advantages, however, the scholars also found challenges and limitations of this approach. Students' general reading comprehension level influenced students' understanding of APL texts. Whereas the canonical structure boosts comprehension, some students develop an idea that all science in the real world is an ordered process similar to the way science articles are organized (Falk & Yarden, 2009). Falk and Yarden (2009) also note students' difficulty with reading discussion. Even though some studies also recognized the advantage of reading discussion that help students understand the uncertainty of scientific knowledge as well as the importance of arguments, some students, on the contrary, experienced difficulty with reading discussion. The students identified that this kind of discussion is foreign to them, and thus it was hard to understand the possibility of new research, the relation to other research, and the limitations of their own research.

2) Disciplinary literacy pedagogy

The disciplinary literacy pedagogy approach explicitly focuses on the importance of understanding disciplinary nature when one engages in literacy activities, especially around student reading. Moje (2007) suggests that learning a subject matter is not merely about learning the product of disciplines; it is more about understanding the processes and practices by which the product is produced. Therefore, she argues that understanding and production of disciplinary texts requires knowing how members of the disciplines think and write. Producing such texts must involve an understanding of the goals of the writing task as well as the perspectives and interests of the target audience. This notion that learning discipline requires an epistemological understanding of the process of knowledge production reflected in texts is strongly consonant with the highlighted importance of argumentation practice in science education. Scientific argumentation, by definition, is knowledge building and the process of validating such knowledge, which makes science knowledge different from other disciplinary knowledge (Driver *et al*., 2000; Duschl & Osborne, 2002). Students, thus, were expected to develop such an understanding through argumentation practice.

Scholars in this approach are interested in characterizing and developing texts that reflect the ways in which scientists think and how scientists use these texts to enhance students' understanding of disciplinary nature. Some early researchers in disciplinary pedagogy specify the cognition of members of the disciplines as they either comprehend or produce oral and written texts (Moje, 2007). They compare these identified cognitive processes of disciplinary members with learning in the subject matter area (Collins, Palincsar, & Magnusson, 2005; Hand *et al*., 1999; Hand *et al*., 2004a, 2004b) and apply this cognitive process to educational practice (Hynd *et al*., 2004; C.D. Lee, 2005; Moje, 2007). Hand and his colleagues focus on Science Writing Heurstic (SWH)(Hand *et al*., 2004a, 2004b). They suggest that better writing could be achieved using the SWH strategy for every step of the science investigation, especially through reading and comparing one's own and others' arguments. By reading others' arguments, students have opportunities to reflect and evaluate the quality of the claim, the evidence, and its coordination to support the argument. Moje and her colleagues (Moje *et al*., 2004; Textual Tools Study Group, 2006a) engage students in reading both scientific and lay-audience texts. Students are asked to interpret multiple data representations, which require developing explanations to make sense and communicate. Students then participate in peer review activities in which they evaluate and compare what they originally hypothesize with the results they have and what those results mean related to their original claims. Through these activities, students develop an understanding of different kinds of claims, whether based on the prediction of observational phenomena or based on simple inference (Moje *et al*., 2004; Textual Tools Study Group, 2006a). They also evaluate how evident the presented data are in relation to the claims, and thus whether the argument is rhetorically appropriate (Textual Tools Study Group, 2006a). Students demonstrate enhanced understanding regarding rhetorically appropriate characteristics of scientific arguments and explanations.

3. Claim, Evidence and Argument

The most common conventions for categorizing scientific claims are hypothesis, theory and law. Hypothesis is a confirmed or falsified tentative explanation for an observation. A theory is a coherent set of repeatedly tested statements, which explains why something happens. A law describes what happens with a mathematical equation. In the literature of scientific argumentation, however, scholars commonly use the definition from Toulmin's Argument Pattern (Osborne *et al*., 2004). According to them, a claim is "an assertion put forward publicly for general acceptance" Regarding evidence, evidence is data or a statement that supports a claim. Evidence typically consists of quantitative or qualitative measurement. Argument justifies claims with evidence. When highlighting the process of developing argument, dialogic and social aspects are highlighted—two or more people try to persuade and convince others of the validity of knowledge claims with evidence. In the center of defining the meaning of argument, claim and evidence are crucial elements.

4. Capturing Epistemic Ideas From Argumentation Practices In Science Classroom

Recently, some studies captured students' epistemic understanding of science as they engaged in argumentation practices. Ryu and Sandoval (2012) examined whether and how students' sustained participation in scientific argumentation influence their epistemic understanding by using pre and post argument construction and evaluation tasks. They also incorporated the results of these tasks into their observation regarding argumentation norm development over the year. They investigated four criteria, causal structure (science aims to provide the causal explanation of natural phenomena), causal coherence (scientific arguments advance chains or networks of causal inferences), citation of evidence (scientific arguments cite the data that claims are meant to explain), and evidentiary justification (scientific argument explicitly justify the relationship between claims and evidence). They found that students showed improvement in their understanding of epistemic criteria and understood better about evaluation of evidence and the fit between evidence and claims. While students used somewhat ambiguous criteria such as good, clear, specific and detailed in the pre- tasks, they growingly referred specific epistemic criteria such as causality, number of evidence and providing justification. However, students' initiative epistemic ideas were not fully addressed because these researchers only used written answers. McNeill examined students' epistemic ideas about evidence, explanation and argumentation. She interviewed students before and after taking argument-based instruction and compared their ideas. She also investigated student epistemic ideas in different contexts (i.e. everyday, science classroom, scientists). According to her research, while the majority of students rarely showed any specific ideas regarding scientific explanation or argumentation in pre-interview, as they simply answered, "I don't know", they developed some sophisticated ideas in the post interview such that how or why a phenomenon occurs or exchanging ideas between people. However, she stressed that students rarely discussed the role of evidence when they talked about argument. Students rarely discussed about the role of data when they talked about evidence. Therefore, further research needs to be conducted to address students' epistemic ideas of fundamental, basic terms in scientific argument, including claim, data, evidence and justification. In summary, students' practice in reading scientific arguments, and engaging in the activity of evaluating and critiquing argument has been supported in two ways: students are asked to read the adapted version of scientists' arguments or they are asked to compare two arguments of different epistemic and rhetorical quality. Through reading scientists' texts, students could develop a sense that scientific argument is not a declaration of absolute facts, but rather a continually examined theory. The genre-specific nature of text structure helps students understand such nature. When comparing two arguments, students could learn and examine what counts as a scientific argument, in particular by comparing the link and coordination between claim and evidence.

Below is a scientific argument.
(S1) A scientist told Mark's class that introducing more salt water to the San Francisco Delta killed most of the invasive clams that had been growing there. (S2) Mark believes that this suggests altering abiotic factors in an ecosystem can control invasive species. (S3) He reasons that a decrease in salt levels in the San Francisco delta allowed invasive clams to survive better than the native clams that were used to higher salt levels in the water.

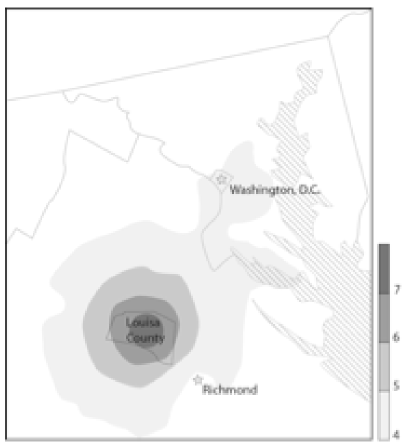
Which answer best describes how the argument is organized?

a. (S1) CLAIM- (S2) EVIDENCE- (S3) OTHER
b. (S1) CLAIM- (S2) OTHER- (S3) EVIDENCE
c. (S1) OTHER- (S2) CLAIM- (S3) JUSTIFICATION
d. (S1) EVIDENCE- (S2) CLAIM- (S3) JUSTIFICATION

Figure 1. Text-based argument

Carla and Zach are in Mr. Thomson's class. They live in Washington D.C. and felt their first earthquake in 2011. Carla knows that earthquakes can cause a lot of damage. She has a friend in California who saw an earthquake destroy many buildings in her city. Mr. Thomson asked the class: Why are some earthquakes stronger than others?

Carla wondered if earthquakes are stronger at their epicenter – the earthquakes' starting point. She did some research and found the map below. The map shows where the 2011 Virginia earthquake started. It also shows how strong the earthquake felt at different distances from where the earthquake started. The numbers on the map describe different strengths of the earthquake at different locations.



Strength	Perceived Shaking
1	Not Felt
2	Weak
3	Slight
4	Moderate
5	Rather Strong
6	Strong
7	Very Strong
8	Severe
9	Violent
10	Intense
11	Extreme
12	Cataclysmic

Figure 2. Data-inscription argument

III. Method

1. Setting and Participants

This study took place in a junior-middle school in Seoul, Korea. In total, 56 students (30 boys, 26 girls) participated in the study. They volunteered for the interviews from two after-noon science, creation and intervention classes. The teacher, Ms. Park (pseudonym) had been teaching for 3 years with a chemistry education degree, and she reported in her interview that she rarely included any explicit teaching regarding argumentation in her science classes.

2. Reading Tasks

Reading materials were written at the middle-school level and involved concerned Earth science or life science. Experts in science content, literacy, and scientific argumentation reviewed the materials for content validity and the accuracy of translation (from English to Korean). At the time of this study, students had not learned the content in the reading materials in classes. Thus, their prior familiarity with the content depended on their own personal interest and knowledge. Each argument included a topic statement and some background information (e.g., definition of epicenter). This allowed students to obtain necessary information.

1) Text-based Arguments

All text-based arguments avoided the inclusion of data- representations such as tables, maps, or graphs. Students were asked to read 1) a single argument with a simple text structure (one sentence providing a claim, one sentence providing evidence, and one sentence providing reasoning (justification); 2) a single argument with a relatively complex text structure (one/two sentences providing a claim, one/two sentences providing evidence, one/two sentences providing reasoning, and one/two sentences providing other contextual

Table 1. Types of Questions and Prompts

Types of situated interview questions	Verbal prompts
Meaning	What does “data” mean to you in this text? So, what made you think that this is a claim? Why do you think this sentence is evidence but this sentence is not? If this is your evidence, what are the “others?” What if you explained the meaning of this question to your fried (your younger sister)? How would you explain it?
Paraphrase	Can you repeat the question in this task (or that I just asked) in your own words? What does this question ask?
Item-specific	Can you tell me how you went through this table? Can you clarify what made you decide these were claims/evidence?
General/perception	How did you arrive at that answer?

information); 3) and compared two arguments with a complex-structure. For the items, students were first asked to locate the claim, evidence, and reasoning from each argument. Then, they were asked to describe the ideas or criteria that they used to identify the components or that they thought made the sentences one component over another (Figure 1).

2) Data-inscription Arguments

All data-inscription arguments include one or two data-inscriptions along with some description of the context. Students were asked to read 1) an argument with one simple map and one simple table; 2) an argument with a map including a legend (earthquake intensity legend); and 3) an argument with multiple columns in a table. Through the items, students were asked to describe the ideas or criteria that they used to identify the components. This was done to determine the form of justification used, as well as the soundness of the evidence. This enabled us to address how students use and interpret data-inscriptions as evidence and how they coordinate their claim and the evidence to justify their argument (Figure 2).

3. Student Interview

Students were pulled out of the classroom to be interviewed individually in a science-preparation room. At the start of each interview, the interviewer instructed students that they would read short passages regarding Earth or life science topics. The students were told that the interviewer would ask them “how you make a decision” or “how you figure out something.” The interview focused on addressing students’ epistemic ideas of claim, data, evidence and justification. The interview also attempted to address where students’ ideas came from. When students referred to specific terms (e.g. this sentence is evidence), the interviewer asked the student to provide his/her ideas. Because the questions in the tasks explicitly asked students to identify and locate the claim, evidence, and reasoning, the interviewer was able to situate the questions naturally.

The interviewer also used four types of verbal probes, including meaning, paraphrasing, item specific (i.e., data-related) and general (i.e. initiation or comprehension) questions. Table 1 shows the types of situated clinical questions that were associated with the example of the verbal prompts. Although the interviewer prompted students’ answers by using questions, contingent upon the situations encountered, the interviewer did not direct the students’ responses.

IV. Data Analysis

The analysis of student interview focused on the investigation of students’ epistemic ideas about claim, data, evidence and argument. All student interviews were fully transcribed, used to develop coding schemes and code data. Coding schemes were developed to capture students’ ideas about claim, data, evidence, and coordination between the claim and ideas in the context of text-based arguments and arguments using data inscription. The coding scheme was also informed by previous research examining elementary students’ epistemic ideas (McNeill, 2011) as well as students’ everyday meaning of these terms (Bricker & Bell, 2008). The coding scheme was developed iteratively, synthesizing a top-down and grounded approach. The coding scheme was first developed based on a grounded theory approach to capture students’ expressed epistemic ideas (Corbin & Straus, 1990). Next, the codes identified from this ground approach were compared and incorporated existing codes regarding students’ ideas about claims and evidence.

V. Findings and Discussion

The analysis of the interviews revealed students’ epistemic ideas of the meaning, role and relationship of these terms. The finding focuses on the presentation and illustration of most common ideas, rather than capturing all ideas that students represent.

1. RQ1. What are Korean middle school students’ ideas about claim, data, evidence and argument in the context of text-based and data-inscription arguments?

Claim should be a unique and creative idea The most frequent idea students addressed was that claim is a unique and creative idea. For example, a 7th grade boy student stated, “O.K. These scientists discovered that more salt water coming from SanFrancisco. Because he discovered this, this is a claim” Students’ such idea of new and creative ideas as claim seems to reflect the recent emphasis of science education, which highlights the contribution of new, creative ideas to the development of science and technology. In addition, since these students were members of afternoon science intervention class,

Table 2. Student Epistemic Ideas of Claim

	Dimension	Student idea	Example	Response rate
CLAIM	Role	Scientists' unique and creative idea	O. K. These scientists discovered that more salt water coming from San Francisco. Because he discovered this, this is a claim	39% (22)
		Introducing what scientists found/discovered	But scientists introduced an idea that some organisms have evolved to be completely dependent on one another for survival.	30% (17)
		Emphasizing a main idea	This states the strength of earthquake and its relationship with distance. Here, it says how strong the earthquake felt at different distances	25% (14)
		No claim found	I don't think she makes any claim. She just tries to explain some phenomenon about earthquake.	5% (3)
	Criteria	When it sounds very certain and objective	I think S1 is, because it sounds very certain and scientific. Because he points to an important science study about ecosystem. It shows the clam did not survive well in California when green calm was introduced.	45% (25)
		When it delivers a clear idea	A claim should be very clear about what is claimed. This scientist clearly said what she wanted to say in her first sentence	34% (19)
		When it is a brand-new idea that others did not think of	To be a scientific claim, one needs to develop something new, like no one thought about that before.. you know, Einstein and Galilei? This scientist talks about why Bees disappear	13% (7)
		When it answers a question	Earthquakes are stronger at their epiccenters. This answers Mr. Thomson's question about why some earthquakes are stronger than others	9% (5)
	Task result	On average, 93% of students could locate a claim correctly.		

creative and unique idea seemed to be highlighted. Another idea that students addressed is that claim is a hypothesis and prediction before conducting experiment. Most students believe that scientific claim should be tested through conducting experiment.

Role of evidence highlighted in an argument while previous studies conducted outside of Korea report that students barely discussed the role of evidence in scientific argument (McNeill, 2011), these Korean students highlighted the role of evidence in a scientific argument. When talking about science argument, Korean students, in particular, boys specifically mentioned the importance of evidence of argument in relation to the investigation of crime. For example, A 7th grade boy stated "Think about investigation of crime scenes, we have to show a number of evidence to prove someone's crime. Developing a scientific argument is just like the investigation of crime. You have to show evidence that supports your idea, otherwise people never

Table 3. Student Epistemic Ideas of Data and Evidence

	Dimension	Student idea	Example	Response rate
DATA & EVIDENCE	Role	For recording facts vs. For proving, showing, stating results and conclusion	when reading something you may find many interesting things. Sometimes, people just show and state many interesting points together. But, you have to be very careful about selecting evidence because evidence should determine whether the idea is right or wrong.	39% (22)
		Showing specific example, measurements and observation vs. Identifying sources and methods	Data are kinds of specific examples from measurement or observation. like, this is data what someplace has no green claim any more, something like that. To be evidence, you have something that others can see that is true. So you have to say where this comes from and how it is done so other people can see if the idea is really true.	34% (19)
		Collected from conducting experiments vs. Supporting a main idea and help to prove it.	you can get data when you conduct experiments. These are called, data. Among these data, data that help you support and prove your hypothesis, that's evidence.	27% (15)
	Criteria	When sounds like real facts (data)	Data are not something out there, they are real facts, gathered from investigation and experiments. They are collected in a scientific way. It is not just one can say that just make it up	32% (18)
		When more data are available (data)	Not every single piece of information becomes data. Data should be a set of information corresponding to specific variables.	27% (15)
		Evidence is something somebody has solved to prove how it was engaged (evidence)	Evidence should be able to prove whether the idea is right or wrong	48% (27)
		Evidence is testable and replicable (evidence)	Other people should be able to find same evidence. Otherwise, we do not know whether they are trustworthy	39% (22)
	Task result	75% of students identify data correctly. 23% of students do not distinguish data from claim and included claim as data.		

believe and they never know whether it is true or not" Some students also seem to clearly acknowledge the need of providing justification that explains evidence. A 7th grade girl said "You have to make sure that others understand what your observation means and how your inference comes from using reasonable explanation"

Students also made a clear distinction between data and evidence. When the interview asked about the difference between data and evidence, a 7th grade boy clearly indicated, "when reading something, you may find many interesting things. Sometimes, people just show and state many interesting points together. But, you have to be very careful about selecting evidence because evidence should determine whether the idea is right or wrong. In other words, anyone should be able to know that the idea is right or wrong when seeing evidence" Regarding data, the same boy stated "data are something that you collected, researched and observed, but not all of them are evidence. Again, evidence should be able to prove whether the idea is right or wrong"

However, Korean students indicated that there is (should be) only one way of interpreting the data. Although they differentiate the role of evidence and data, only 30% of students were able to identify a piece of data that weakens a claim. Similarly, only 25 % of students correctly determined whether the data strengthened or weakened the claim of the argument when new data were added, and introduced to students.

This is particularly interesting because previous studies nominated students' incapability of differentiating data and evidence may contribute to the idea of single-available interpretation. Although these students were able to make distinction between data and evidence, they still hold the idea that data must be interpreted in a single way. When students hold this kind of idea, it could prevent students from understanding that some data could weaken or contradict the claim. That is, when students were asked to compare two students/scientists' argument, they might not be able to think that these two students/ scientists deal with same data but interpret them differently. Rather, students seemed to think that one must make mistakes or select wrong evidence.

Argument is for proving truth Students' ideas of argument focused on the role or purpose of argument, rather than defining the meaning of argument per se. An 8th grade boy stated "when scientists have different ideas, they have to argue until they get the truth" Similarly, A 7th grade girl also said "people have to make a decision on some point so scientists do, too. If they don't agree on something and they have to try hard and find a way to figure it out. So they argue" As shown, students'ideas of argument focused on proving truth whereas they hardly indicated the process of building argument as the process of building scientific knowledge.

This finding is interesting, which calls for more research on Korean student's epistemic understanding of scientific argument. That is, different from previous studies (in particular, those studies conducted in the U.S), Korean students showed more sophisticated understanding of the role of claim and evidence in argument as described above. Despite this sophisticated understanding, however, these students still think that the main role of scientific argument is to prove truth, which seems to be ironic considering their enhanced understanding of the role of claim and evidence. From interview data and task results gathered in this study, it is difficult to answer what factors may attribute to such idea. A conjecture from student interviews, though, is that students seem to think that scientists are likely to disagree and argue only when the issue of truth or false is appealed.

Table 4. Student Epistemic Ideas of Argument

	Dimension	Student idea	Example	Response rate
ARGUMENT	Role	Prove truth (correct or wrong)	When scientists have different ideas, they have to argue until they decide which one is right	45% (25)
		Make a story connect	Teacher asked why some earthquakes are stronger than others. you have a map that shows distance from the center makes the earthquake strength different. Then you have to put these two together nicely	21% (12)
		Explain how and why something happens	people have to make a decision on some point so scientists do,too. If they don't agree on something and they have to try hard and find a way to figure it out. So they argue	20% (11)
		Resolving disagreement and have them focus on ideas rather than personal feelings	When people disagree with each other, sometimes they do not like each other and have some history, like fighting. Having an argument can make them focus on ideas rather than their feelings so they resolve their disagreement	14% (8)
	Criteria	When it makes someone understand	It is hard to understand when you say "bees are going to disappear and you are not going to see bees" So scientists explain it so people understand.	38% (21)
		When it convinces/ persuades others	Scientists, just like us, develop an argument because they want us to believe them, believe their theory	34% (19)
		When it clarifies ideas	I was thinking that some places have safer, solid and newer buildings and other placers are not. That's why people feel the strength of earthquakes different. However, reading argument clarifies the ideas of distance from the center.	29% (16)
	Task result	55% of students could summarize the argument described both in data-inscription and text-based arguments.		

2. RQ 2. How does the genre-specific text structure and the characteristics of data-inscriptions affect students' epistemic decisions?

Using discourse cues to determine argumentative components In the context of reading text-based arguments, students were able to identify argument components better when they recognized a causal or sequential structure of arguments by identifying logical connectives or discourse cues. These Korean students recognized some rhetorical cues and indicators of claim and evidence, and incorporated such ideas into their understanding or previous exposure of contents. Students instantly recognize the words such as say, assert, claim and find as indicators of claim sentence. Different from previous studies, these Korean students did not particularly prefer the first sentence as the claim. They also do not prefer the most short sentence as the claim.

Table 5. Logical Connectives and discourse cues identified to determine argumentative components

Argumentative components	Logical connectivities and discourse cues
Claim	say, argue, state, assert, highlight 말하다, 주장하다, (과학자에)-의하면, 강조하다
Evidence	show, discovered, find 보여주다, 발견하다, 찾다
Justification	because, as, if~then 왜냐하면, ~ 때문에 ~경우를 고려할 때

For example, a girl student stated:

"This sentence is claim because the sentence used a word, discovered. That's a claim. And, I know bees are decreasing recently, and he says that too. That's claim. This is observation but there is no data measured. This is observation. O.K. This is scientific inference because he relates the climate change to bee's population change" This student seemed to use her understanding of discourse cues (i.e. discover as claim) incorporated with her previous knowledge about bee population issue"

Preferring measured data as evidence Korean students recognized measured observation and data as evidence. They were very reluctant to identify described texts as evidence although they identified them as important information. Students indicated that methods or sources of evidence must be included to be counted as evidence. Students tended to prefer data inscription as evidence as they think these show how data are collected and changed over time. They indicated that they preferred this because scientists usually follow official and formal ways of conducting experiments that show clearly where evidence comes from. Students answered that justification makes a story make sense and connect, which is consistent with the current understanding of justification from the science education literature. Students seemed to understand the coordination role of justification that connects claims and evidence.

It is known that students take making sense as the goal of arguments instead of persuasion to demonstrate an answer that is conceptually correct. Similarly, students' epistemic ideas seem to be influenced by their goal of pursuing conceptual/content understanding. For example, students view evidence as important and constituting new information. The degree of importance seems to be determined by how this information helps them to understand a presented concept/content instead that how the information support claims. Similarly, students also indicated that data-inscription automatically becomes evidence without justification in that it is used to assist in understanding of a science concept or content, which makes students think that there is only one way to interpret data.

VI. Conclusion and Implications

This study was designed to address students' epistemic ideas as they engage in relevant task—reading arguments and evaluate them. The study also attempted to see how students analyze and evaluate text-only arguments and data-inscription arguments because younger students are likely to find only numbers, recorded from measurement as data and evidence, and relatively ignores other described information. When comparing students' ideas from text-based and data-inscription arguments, students preferred data-inscription as evidence when both were available. Students were less likely to take qualitative description (text-based description) although they recognized the importance of the description.

Students seemed to be more comfortable with taking about these terms because they were in the process of analyzing and evaluating them. However, it was still challenging to address students' epistemic ideas because students' epistemic ideas seemed to be drawn from multiple resources from their everyday, school science and professional science and express their ideas in a mixed way.

For designing learning environment for instruction and assessment, our findings suggest that the effort to address and improve younger students' epistemic ideas should go beyond merely focusing on asking a direct question content understanding because traditional instruction and assessment materials seem to contribute to the objectification of data-inscription, seeing it as the means of delivering science concept. To design a learning environment or assessments to promote students' epistemic understanding, therefore, it is important to design genuine, real-world scientific texts and data inscriptions in which multiple interpretations and explanations are salient and available for students, so they see data are open to multiple interpretations, and thus justification for data is necessitated to be counted as evidence.

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