

The Argumentation and Evaluation Guide: Encouraging NGSS-based critical thinking

By Janis Bulgren and James Ellis

Argumentation—the process of using evidence to support and explain a scientific claim—plays a key role in the *Next Generation Science Standards* (NGSS Lead States 2013). To help students identify a claim and evaluate the evidence and reasoning presented in support of the claim, a new tool has been developed—the Argumentation and Evaluation Guide (AEG). The AEG is a graphic organizer used to depict the key elements in analyzing a claim and its supporting argument. The AEG contains an embedded reasoning strategy, the Argumentation and Evaluation Strategy (AES), and is co-constructed with students using the Argumentation and Evaluation Routine (AER) (Bulgren and Ellis 2012; Bulgren, Ellis, and Marquis 2014). In this article, we will focus on how you can use the AEG to enhance argumentation in your classroom. The AEG may be used to evaluate a claim made by others, as shown in the following example. In addition, students may use it to make and explain their own claims based on evidence from laboratory experiments.

Steps of the AEG

The teacher begins by providing students with a blank AEG and copies of an article containing a claim. By allowing students to preview the blank AEG, teachers give students the opportunity to see what will be expected of them during the claim-argumentation process. Next the teacher and students collaborate to complete the AEG.

As the teacher and students work through the AEG, they will be completing nine steps that represent the flexible, cognitive reasoning strategy that guides students and teachers as they evaluate arguments made in support of claims. Figure 1 is an AEG that was created to address the claim: “An organism without a brain (amoeba, *Physarum polycephalum* [PP]) shows some signs of intelligence, defined as the ability to acquire knowledge and skills.” Figure 2 presents a script a teacher could use to guide students through the AEG as they examine the

mentioned claim. This script illustrates three components of the instructional procedures in the Argumentation and Evaluation Routine. It illustrates how a teacher (a) initially *cues* students to participate in the analysis and evaluation of the claim with statements about importance of the learning and expectations for participation, (b) *engages* students in the discourse about and collaborative development of the AEG, and finally (c) *reviews* with students the learning that resulted from the use of the AEG and the process by which that learning occurred, that is, using the strategic approach contained in the AEG. Figure 3 presents a rubric that you can use to assess students’ completed AEGs and provide students with feedback on their performance.

The following section explores each of the nine steps of the AEG and explains how they specifically address Science and Engineering Practices (SEP) found in the NGSS.

NGSS SEP: Asking Questions (Step 1)

The NGSS emphasize that asking questions is critical to developing expertise in science. Specifically, students are asked to evaluate questions that challenge the premise of an argument and to interpret data. For example, students might have a question as to the believability of a claim being made in an article, in a video, or on the internet.

To support this goal, the first step on the AEG begins with a guiding question: “What is the claim?” Working from this prompt, students identify the claim being made, including any qualifiers to the claim. Other questions launch subsequent steps on the AEG.

NGSS SEP: Analyzing and Interpreting Data (Steps 2, 3, and 4)

The NGSS specify that students consider the tools and technologies used to generate and analyze data to

FIGURE 1 Sample AEG on intelligence in amoeba

Argumentation and Evaluation Guide

Topic: Intelligence in Amoeba _____ Name: Marie J. _____
 Title: Brainless Intelligence _____ Class: Biology _____
 Source: Journal studies _____ Date: May 7, 2015 _____

1 What is the **Claim**, including any **Qualifiers**? Are there qualifiers? **Yes/No**. (If yes, underline them.)
 An organism without a brain (amoeba, *Physarum polycephalum* ([PP]) shows some signs of intelligence, as defined as the ability to acquire knowledge and skills.

<p>2 What Evidence is presented? In column 3, identify the type of evidence with the letter: Data (D), Fact (F), Opinion (O), Theory (T). * Research from the U. of Australia (in <i>National Academy of Sciences</i>) shows PP recall information from slime trails & plan the best path to food. * Research from U. of Paul Sabatier (France) shows PP can discriminate to pick best food from 11 food choices. * Research from U. of Tokyo shows PP learn temperature patterns & adapt movement (published in <i>Smithsonian</i>).</p>	<p>3 4 What chain of reasoning (warrant) connects the evidence to the claim? In column 6, identify type of reasoning with the letter(s): for AUTHORITY (A), THEORY (T), or type of LOGIC: Analogy (AN), Correlation (C), Cause-Effect (CE), Generalization (G)</p> <p>D Since research by good authorities (published in journals) shows that PP can recall, discriminate and plan ahead, and since these are signs of intelligence, and since PP have no brains, then evidence supports the claim that some organisms without brains show signs of intelligence.</p>	<p>6</p> <p>A T G</p>
<p>4 Evaluate the quality of the evidence as poor, average or good. Explain your evaluation.</p> <p>Reliable Good – there were different studies Valid Good – they studied the same amoeba Objective (no bias) Good – reputable institutions Methodology Good – controlled variables, repeated studies</p>	<p>7 Evaluate the quality of the chain of reasoning as poor, average or good. Explain your evaluation.</p> <p>Strength of Authority Good – reputable institutions Application of Theory Good – accepted intelligence theory Type of Logic Good – generalization</p>	

8 What are your concerns about the believability of the claim? (your counterarguments, rebuttals or new questions?)
 The claim seems believable, but I think we have a lot to learn about amoebas.

9 Accept, reject, or withhold judgment about the claim. **Explain** your judgment.
 I accept the claim because there were good studies from good institutions, and since theory indicates that if an organism can recall, discriminate and learn, then those are signs of intelligence.

make valid and reliable claims, and to consider limitations to the strength of the claim based on those data. For part of this process, students are asked to analyze various types of data.

In response, steps 2, 3, and 4 of the AEG support students as they analyze and interpret data or other forms of evidence. As illustrated in step 2 of Figure 1, studies may present evidence about the amoeba’s ability to recall information, discriminate among food choices, and plan how to adapt movements based on temperature patterns. In this example, all three items of evidence are based on data from studies, as identified in column 3 with the letter “D.” In addition to data, the AEG prompts students to also consider evidence in the form of facts, opinions, and theory. Furthermore, in step 4, students are supported as they evaluate the quality of the evidence as poor, average, or good; this evaluation may be based on reliability, validity, objectivity, and methodology of research. (See Steps 2, 3, and 4 in Figure 1.)

NGSS SEP: Engaging in Argument from Evidence (Steps 5, 6, and 7)

The NGSS expand the challenges students face to include ways of analyzing reasoning. Across the grades, students must consider appropriate and sufficient evidence and scientific reasoning behind explanations made to determine the metric of an argument, and construct counterarguments based on data and evidence.

Steps 5, 6, and 7 of the AEG guide students as they analyze the reasoning that the person(s) making the claim uses. In traditional argumentation, this is often called the warrant. The warrant is the reasoning about how well the evidence supports the claim. In the AEG, the warrant is called the *chain of reasoning*. This term was selected to convey that all parts of an argument must be considered as a sequence.

To illustrate, an argument may be thought of as consisting of links in a chain. The first link in the chain

is the claim itself, the second is the evidence given to support the claim, and the third is the reasoning about how the evidence was used to support the claim. A good example of an evaluative statement about the chain of reasoning in step 5 could fit a pattern such as:

*“Since research (authority) shows that *Physarum polycephalum* (PP) can recall, discriminate, and plan ahead, and since these are signs of intelligence (theory), and since PP have no brains, then the evidence*

is well used to support the claim that some organisms without brains can show signs of intelligence (generalization).” In addition to a “Since ..., then ...” explanation of an author’s chain of reasoning, others might be supported by explanations in the form of “Because... , therefore, ... ” or “As evidenced by ... , we can conclude that ... ,” and so on.

Sometimes these terms are implied. For example, a conclusion that reads, “Accept the claim. Our ex-

FIGURE 2 Sample script to guide students through the AEG

CUE Learning Goals and Expectations

Today we will be using the Argumentation and Evaluation Guide (AEG) to analyze an article on an amoeba. I am passing out an article and a blank AEG. Please participate in the discussion as we analyze and evaluate the claim and argument made in the article, and use the blank Guide to record your findings. This article is important because it presents interesting new studies about intelligence in an amoeba. Remember as we analyze and evaluate the claim in the article individually, in pairs, or as a whole group, we will collaborate, share, and confirm our thinking.

For this portion, please work with your lab partner. After we discuss the article, you will fill out an AEG in pairs, and then we will discuss as the whole group. *(Pass out the blank AEG and a copy of the article on intelligence in amoeba.)*

ENGAGE students in collaborative development of the AEG

What information is asked for in Section 1 of the AEG? *(Pause for student responses.)* Yes, it is asking for the claim with any qualifiers. With your partner, discuss what CLAIM is made in this article. Do not write anything on your AEG until we discuss the claim as a class. *(Allow a minute or so for students to find and discuss the claim and then discuss as a group.)* Elicit student responses that may take forms similar to the following:

“I think it says that an organism without a brain can think.”

“Well, I wonder whether ‘thinking’ and ‘signs of intelligence’ are the same?”

“We also have to remember the statement has the qualifier ‘some.’”

Okay, now that we have discussed ideas about the claim and its qualifier as a class, work with your partner to write down what you think is the claim being made in the article. As we continue discussion, feel free to add ideas to the AEG you and your partner are developing.

Now, in Sections 2, 3, and 4, we will look at the evidence presented. What evidence in the form of data, facts, theory, or opinion do you find in this article that supports the claim that an organism without a brain can show signs of intelligence? Please work with your partner to find evidence that supports that claim, and write this in Section 2. Then identify the type of evidence in Section 3. *(Allow students to work together about three minutes to identify evidence, and then open the class discussion. Elicit from members of the class that evidence includes the data from studies by researchers who appear to be qualified.)* Elicit student responses that may take forms similar to the following:

“I see researchers at three universities. That has to be pretty good research.”

“Where the results were published looks good, too.” *(Allow students time to rate the types of evidence as “good,” “average,” or “poor” in Section 4.)*

Let’s move on to Sections 5, 6, and 7 of the AEG as we analyze how the authors used reasoning to support the claim with their evidence. This is the *chain of reasoning*, sometimes called the *warrant*. Working with your partner, develop a succinct statement that reflects the reasoning the authors used to convince us that their evidence supported the claim, and write that in Section 5. Then, identify the types of reasoning used by the author. *(Allow the pairs about two minutes to review the article. Ask them to identify in the column labeled with the number “6” the type of reasoning used*

periments and the kinetic theory of matter support the claim” is, in essence, a *since–therefore* evaluation; i.e., “*Since* our experiments and the Kinetic Theory of matter support the claim, *therefore* the claim is accepted.”

Of particular relevance to the NGSS are the distinctions among types of logic such as cause-and-effect logic versus correlational logic, or the use of reasoning by analogy, or in this example, generalization. These are identified with letters in Column 6, and evaluated

as good, average, or poor in Section 7. A cause-and-effect relationship is of particular importance because it is one of the Crosscutting Concepts in the NGSS and can provide strong support for a warrant. (See Steps 5, 6, and 7 in Figure 1). In addition, evaluation of an argument continues in Step 8 in which students consider counterarguments, rebuttals or new questions. Therefore, Step 8 is a bridging step that is also used in

(continued on page 84)

FIGURE 2 Sample script to guide students through the AEG

(authority, theory, analogy, correlation, cause–effect, or generalization). Elicit student responses that may take forms similar to the following:

“Well, all the research would mean it has good authority.”

“There seems to be some theory when signs of intelligence are defined.”

Working with your partner, discuss and evaluate whether the author used good logic, sound sources of authority, and accepted scientific theory in the previous section. *(Prompt the students to write this information on their individual AEGs in Section 7 and rate the quality of the reasoning.) Elicit responses that may be similar to the following:*

“I think the authority, theory, and generalization all seem good.”

“I agree.”

(Allow students time to rate the reasoning as “good,” “average,” or “poor.”)

Now, in Section 8, consider with your partner whether there are CONCERNS, that is, anything you want to bring up that you think the author has not considered. This could include other things you know that would lead you to a different claim (a counterargument), any facts that would prove the claim wrong (a rebuttal), or just new questions that you think should be investigated related to the claim. *(Allow students to work in pairs about two minutes to come up with concerns, and then discuss as a group, and ask the students to write their concerns on their own AEG in Section 8.) Elicit student responses that may take forms similar to the following:*

“Well, I think there needs to be more research in this area.”

“I would really like to know more.”

We are now in the final part of thinking about the claim, Section 9, that is, your own CONCLUSION, or the opinion that you have reached by thinking about the claim. This is important because it is your own judgment and evaluation about the claim. Please work with your partner to decide whether you want to accept the claim, reject the claim, or withhold judgment until you can find more information. *(Allow the students to talk to their partners about a minute, and then call on volunteers to share their thinking with the class. After this discussion, ask the students to write on their own AEG whether they have accepted, rejected or withheld judgment of the claim, and explained their reasoning in Section 9. Prompt students to explain WHY they accepted, rejected, or withheld judgment on the basis of evidence and chain of reasoning.)*

REVIEW Learning and Process

Now, let us review WHAT we learned, and HOW we learned it. First, now that we have analyzed the claim in the article, let’s review what we have learned. *(Elicit from students the claim, evidence, reasoning, concerns, and their conclusions. Allow time for discourse on different points of view.)* Second, let’s review how we analyzed and evaluated the claim. *(Ensure that students understand the steps on the guide, how they represent a strategic approach to analyzing different types of arguments, and how the same steps can be used with a variety of claims to generalize their understanding.)*

That was a great discussion we just had, and your evaluation of the claim, evidence, and reasoning was very complete. Watch for claims you encounter in everyday life that you could analyze with some of these steps.

FIGURE 3

AEG scoring rubric

Step	0 Poor	1 Needs improvement	2 Good progress toward improvement	3 Very good; meets standards	Score
Step 1a: Claim	No response or unrelated response	The student response inaccurately identifies the claim being made or writes a response not structured as a claim.	The student partially identifies the claim being made.	The student accurately identifies the claim being made, including all qualifiers.	
Step 1b: Qualifier	No response or unrelated response	The student response fails to accurately identify qualifier(s) within the claim OR fails to state there are no qualifiers present.	The student partially identifies qualifier(s) that are present within the claim OR fails to state there are no qualifiers present.	The student accurately identifies most of the qualifier(s) that are present within the claim OR correctly states that none are present.	
Step 2: Evidence	No response or unrelated response	The student response fails to correctly cite evidence used in the source to support the claim.	The student accurately cites one piece of evidence used in the source to support the claim.	The student accurately cites multiple pieces of evidence used in the source to support the claim unless only one piece is given in the source.	
Step 3: Identification of types of evidence	No response or unrelated response	The student response identifies information from the source that is not evidence.	The student accurately identifies one piece of evidence he/she cites from the source as data, fact, theory, opinion, or uses a very close synonym.	The student accurately identifies multiple pieces of evidence he/she cites from the source as data, fact, theory, opinion or uses very close synonyms (unless only one piece of evidence is given in the source).	
Step 4: Evaluation of quality of evidence	No response or unrelated response	The student response includes EITHER the evaluation of the quality of evidence OR an explanation based on the source, but not both OR an evaluation and an explanation that does not address quality of evidence.	The student evaluates AND explains the quality of one piece of evidence he/she cites from the source, using terms such as validity, reliability, objectivity/bias, and methodology, or uses a close synonym.	The student evaluates and explains the quality of multiple pieces of evidence he/she cites from the source in terms of validity, reliability, objectivity/bias, and methodology, or uses very close synonyms.	
Step 5: Chain of Reasoning (Warrant)	No response or unrelated response	The student response fails to explain the author's reasoning connecting the evidence to the claim.	The student explains some of the author's reasoning connecting the evidence to the claim in terms of logic, such as generalization, analogy, correlation, and cause and effect; or uses a close synonym.	The student accurately explains the author's reasoning connecting the evidence to the claim in terms of authority; theory; types of logic, such as generalization, analogy, correlation, and cause and effect; or very close synonyms.	

FIGURE 3

Continued

Step	0 Poor	1 Needs improvement	2 Good progress toward improvement	3 Very good; meets standards	Score
Step 6: Identification of types of reasoning	No response or unrelated response	The student response inaccurately identifies types of reasoning used in the source.	The student accurately identifies one type of reasoning as authority, theory, or a type of logic such as generalization, analogy, correlation, and cause and effect, or uses a close synonym.	The student accurately identifies multiple types of reasoning as authority, theory, or a type of logic such as generalization, analogy, correlation, and cause and effect, or uses very close synonyms.	
Step 7: Evaluation of quality of reasoning	No response or unrelated response	The student response includes either the evaluation or an explanation based on the source, but not both OR an evaluation and an explanation that does not address quality of reasoning.	The student evaluates AND explains the quality of reasoning for one part of the reasoning from the source as authority, theory, or a type of logic such as generalization, analogy, correlation, and cause and effect, or uses a very close synonym.	The student evaluates AND explains the quality of reasoning for multiple parts of the reasoning from the source as authority, theory, or a type of logic such as generalization, analogy, correlation, and cause and effect, or uses very close synonyms.	
Step 8: Concerns of the student	No response or unrelated response	The student response does not state a concern or question from the source or state there are no concerns.	The student raises new concerns, but they are not expressed as counterarguments, rebuttals, or new questions.	The student clearly raises new concerns AND expresses them as counterarguments, rebuttals, or new questions.	
Step 9: Conclusion and explanation about the evaluation of the claim	No response or unrelated response	The student response makes a conclusion to accept, reject, or withhold a decision about the claim OR gives an explanation, but not both.	The student makes a conclusion to accept, reject, or withhold a decision about the claim but provides an explanation of the judgment that fails to include a summary of arguments from the source.	The student makes a conclusion to accept, reject, or withhold a decision about the claim AND provides an explanation of the judgment that includes a summary of arguments from the source.	

Step 9 in which a decision is made and an evaluation is constructed and communicated.

NGSS SEP: Constructing Explanations (Steps 8 and 9)

In this NGSS SEP, students must construct explanations based on evidence consistent with scientific knowledge, principles, and theories; make quantitative and qualitative claims regarding the relationship between variables; apply scientific reasoning, theory, and models to link evidence to claims; assess the extent to which the reasoning and data support the explanation or conclusion; and base causal explanations on valid and reliable empirical evidence.

Steps 8 and 9 of the AEG support the practice of constructing explanations. Step 9 asks students to accept, reject, or withhold judgment about the original claim. In the process, the preceding step 8 encourages students to consider rebuttals, consider counterarguments, or raise new questions.

In the example in Figure 1, students may raise issues such as a need for more research on amoebas, but they also may bring up counterarguments or rebuttals that they may have read about or have thought through themselves. Only then can students complete step 9 by constructing an explanation about their evaluation of and judgment about the claim, evidence, and reasoning. First, they indicate whether they accept, reject, or withhold judgment about the claim. Second, they explain to others how they analyzed the claim, and evaluated or judged its believability, that is, why they made the decision they did. This practice supports the need for students of science to share their thinking with others and engage in discourse as well as inquiry. (See steps 8 and 9 in Figure 1.)

NGSS SEP: Obtaining, Evaluating, and Communicating Information

The NGSS also emphasize the practice of obtaining, evaluating, and communicating information. Students are asked to critically read scientific literature to obtain ideas and then evaluate and summarize complex information. They are further challenged to synthesize, communicate, and evaluate the validity of a claim, methods, and design. These goals are supported by all the steps of the AEG when the evaluation is completed. For example, *obtaining* information is accomplished in steps 2, 3, and 4; *evaluating* information is accomplished in steps 5, 6, and 7. Further evaluation is accomplished with con-

sideration of counterarguments and rebuttals in step 8; and *communicating* information is done in step 9.

This practice is the culminating point for students to demonstrate that they can independently engage in the complex processes of argumentation in defending their own claims, as well as evaluating claims made by others. Students, as well as scientists, must be able to speak or write so that others can understand their thinking. Related to communicating information in writing, findings from research on graphics developed for use with Content Enhancement routines have shown that a graphic, such as the AEG, can guide students as they report their findings in a five-paragraph essay (Bulgren, Marquis, Lenz, Schumaker, and Deshler 2009).

Incorporated into these illustrations of how the Argumentation and Evaluation Routine supports the Science and Engineering Practices is the important understanding that all eight practices are integrated. Therefore, the other practices not specifically contained in the AEG will, of course, be used as students analyze, evaluate, and explain their judgment about a claim. These include Using Mathematics and Computational Thinking, Planning and Carrying out Investigations, and Developing and Using Models.

Connecting to the Common Core

The task of constructing and evaluating a scientific argument, as scaffolded by the AEG, responds to expectations found in the *Common Core State Standards* (CCSS) associated with integrating knowledge and ideas (NGAC and CCSSO 2010). For example, reading standards for literacy in science and technical subjects for grades 6–12 specify that students be able to assess the extent to which the reasoning and evidence in a text support the author's claim.

In addition, both the NGSS and the CCSS support the use of collaboration and discourse. For example, within the NGSS, as students engage in argument from evidence, they are expected to provide and receive critiques on scientific arguments and respond to questions that elicit pertinent elaboration and detail. The CCSS speaking and listening standards ask students to engage effectively in a variety of collaborative discussions in various group structures and with diverse partners. Therefore, aligned with these standards, the AER supports collaborative discourse. See Figure 2 for a sample script of how a teacher using the AER might prompt classroom discourse about signs of intelligence in an organism without a brain.

Conclusion

Argumentation is a major focus of the NGSS, and it is especially prominent in the Science and Engineering Practices. We hope that you will find the Argumentation and Evaluation Guide a useful tool in engaging students in higher-order reasoning and critical-thinking skills associated with argumentation. ■

Note: The Scientific Argumentation Routine manual and associated professional development are available through the University of Kansas Center for Research on Learning website (<http://shop.kucrl.ku.edu>).

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