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Rubrics: Useful Beyond Assessments

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Rubrics: Useful Beyond Assessments

In today's science classrooms, teachers are increasingly required to integrate mastery of core concepts with complex scientific and engineering practices. As a result, teachers must be intentional about selecting scientific practices that align with curricular objectives while also considering how to measure mastery of that practice. For example, scientific argumentation, one of eight science and engineering practices outlined in the Next Generation Science Standards ([NGSS], NGSS Lead States, 2013) is a cognitively complex competency that requires students to simultaneously engage in multiple skills while also exploring important scientific concepts. Scientific argumentation is defined by the NGSS as engaging in "reasoning and argument based on evidence" in order to provide the best explanation of a phenomena or solution to a problem (NRC, 2012). For novice learners, the multiplicity of skills involved in practicing scientific argumentation can be difficult to grasp if the larger practice is not broken down into component skills. The individual skills necessary for engaging in scientific argumentation include the ability to comprehend and analyze text, interpret and collect data, and engage with peers through discussion and writing. Scaffold supports and accommodations are necessary to provide all students in the science classroom with the opportunity to engage in these cross curricular skills.

To that end, utilization of learning progressions is an effective way for teachers to envision the development continuum of the sub-skills necessary for proficient scientific argumentation practices. Learning progressions track students' competency in a specific skill while also accounting for developmental level and instructional scaffolds. A well-developed learning progression for scientific argumentation, like that described by Berland and McNeill (2010), provides a roadmap to mastery of the practice. Further, Osborne et al. (2016)'s model of a science-focused learning progression ensures that teachers could both build student capacity for complex engagement with scientific argumentation while also maintaining realistic learning goals for students. Along with providing formative feedback to students, we argue that incorporating learning progressions for NGSS science and engineering practices can serve as a teacher resource for providing appropriate supports to students and as a tool to sequence needed scaffolds as well as, monitoring individual student's development. Following we provide a brief overview of the types and applications of rubrics and then detail the process we used to develop a multifaceted rubric that deconstructs the complex competency of scientific argumentation into skills that can be used by teachers to guide the development, scaffolding, and measurement of argumentation mastery for all students.

Traditional Rubrics

Rubrics generally fall into two categories, holistic and analytic, both designed to measure and provide feedback to students. Holistic rubrics are based on a single scale to assess different dimensions of a performance as a whole unit; while analytic rubrics break performance into different dimensions and provide descriptive feedback of each facet of performance. Although both rubrics provide valuable instructional feedback to students, hereafter our focus will be on the use of analytic rubrics, as they are more descriptive and detailed and better designed to support use beyond assessments.

Laski (2017) encourages teachers to utilize analytic rubrics in their assessment practices because they capture the smaller skillsets that make up complex tasks. Additionally, analytic rubrics provide an outline of increasingly complex cognitive demands. Creating and using rubrics that detail, not only the knowledge and skills, but also the learning progression of a competency, increases teachers' capacities as they plan for including and engaging all students in their classrooms.

Instructional rubrics, a type of analytic rubric, bridge the gap between rubrics developed for assessment and those that can be used routinely (Andrade, 2000). Instructional rubrics are often developed with student input, enabling them to take ownership and deepen their understanding of content. These rubrics use student-centered language to enable students to take an active role in assessing their achievement on an assignment or even a complete unit.

Although all students benefit from the use of instructional rubrics, they are especially effective when used with students at-risk for or with an identified learning disability (LD). Students with LD often demonstrate difficulties with expressive and receptive language, core academic skills (e.g. mathematics and reading) and knowledge acquisition, retention and retrieval (Therrien, Benson, Hughes, & Morris, 2017). When presented with a complex instructional task, such as engaging in scientific argumentation, students with LD may be unable to fully engage in the practice as their cognitive load capacity is overwhelmed by the demands of the underlying core skills (e.g., reading, communicating with peers, and retrieving core concepts from long-term memory) embedded within the practice. Instructional rubrics can help lessen this cognitive load by targeting an appropriate component skill within the composite skill of scientific argumentation and ensuring the instructional context is not demanding to the point that the student is unable to engage in the practice. The rubric we have developed, and present below (See Figure 1), is designed as both an instructional rubric to help teachers differentiate, support, and guide students through learning scientific argumentation.

<Insert Figure 1 here>

Taking Rubrics Further

Rubrics can help teachers identify discrete skills embedded within NGSS' eight scientific and engineering practices as well as the levels of independence students should demonstrate for mastery of the practice. By developing rubrics that include instructional context, in addition to skill markers, it is possible to guide teaching and learning throughout a unit.

Although scientific argumentation is a complex, cross-curricular skill that students are required to meaningfully engage in during elementary school, research has shown that many students are not given the time and opportunity to practice, develop, or master this important cross-curricular skill (Osborne et al. 2016). The use of a rubric that details a comprehensive learning progression (see Figure 1) can enable teachers to both assess students' mastery at the end of the unit, while simultaneously measuring and facilitating students' development of the component skills that compose scientific argumentation.

To develop the rubric, we began with an analysis of the skills and knowledge necessary to meet the NGSS science and engineering practices performance expectations and learning progressions at the second-grade level (NSTA, 2014). Then, utilizing the competencies of scientific argumentation and levels of knowledge synthesized by Osborne et al. (2016), we divided the four distinct skillsets (claim, evidence, justification and argument) into two levels of competency (identifying/critiquing and constructing/providing). Using NSTA performance expectations for each grade level, the skills and knowledge areas are described in detail to show the increasingly complex path to mastery (novice to advanced). The mastery levels slowly build skills but also simultaneously increase the cognitive load at each competency level (Berland & McNeill, 2010; Osborne et al., 2016).

All of the skills and knowledge components are anchored by the instructional context boxes, intended to guide teachers in structuring a students' instructional experience at each level. Students who are learning to engage in meaningful scientific argumentation, especially those identified with LD, need scaffolding to master each complex set of skills. Berland and McNeill (2010) outline various levels of scaffolding and ways to limit cognitive load to support student development. These recommended levels of scaffolding have been captured in an easy to follow and concrete way in our rubric. Including the accommodations, scaffolding and classroom supports available, teachers can systematically fade supports for students, or build them in as necessary, creating a rich, responsive learning experience for students. The instructional context engages teachers in thinking about how to increase curriculum specific competency, and how to develop executive function, expanding students' capacity for engaging in increasingly complex tasks.

The argumentation rubric can be used with all students, but in particular, it can help teachers differentiate instruction for students at-risk for or identified with LD. For example, a second-grade teacher can create small groups for students with tasks differentiated by instructional context. During a unit on erosion, the teacher can create four stations based on a picture and short narrative of an eroded river. The novice students could then be tasked with identifying the main idea and making general comments about this picture and text, while the advanced students could be asked to evaluate claims made within the text while also generating their own claims about the picture. Further novice students could select, among choices, which measurement instruments were used to collect data about the riverbed erosion, while advanced students could identify the relevant data and use it to support their claims.

By breaking the NGSS science and engineering practice of argumentation down into its component skills, our rubric provides teachers with an access point to start teaching this task to all learners. By using the rubric, teachers can choose how to present the material based on the instructional context: the student can be given the data in isolation, given word banks with vocabulary or sentence starters in order to make and support the claim. If the class is moving on to critiquing claims, or collecting and using their own data to make a claim, these same supports can remain in place to reduce cognitive load and allow struggling learners to focus on the practice of argumentation.

Conclusion

Instructional rubrics enable teachers to differentiate instruction for all students so that they can meaningfully participate in science instruction and master critical scientific practices and core content. Use of a rubric that reduces students' cognitive load is especially important for students at risk for or identified with LD who often are penalized due to their struggle with math and language skills but, when provided instructional scaffolds, are able to master scientific practices. To create a strong instructional foundation, teachers should analyze the scientific and engineering practices in the NGSS and not only think about what students must do to demonstrate mastery, but also how varying instructional context can ensure all students can make progress on learning complex scientific practices and core science concepts.

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Standard 2-ESS2-1 Earth's Systems *https://www.nextgenscience.org/pe/2-ess2-1-earths-systems* The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.	
Performance Expectation	Connections to Classroom Activity *Students:*
2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.	• engage in rubric guided scientific argumentation about river bed erosion
Science and Engineering Practice	
Engaging in Argument from Evidence	• receive instruction modified to meet learning needs and differentiated cognitive loads.
Disciplinary Core Idea	
ESS2.A: Earth Materials and Systems Wind and water can change the shape of the land.	• engage in supported scientific argumentation to make claims about river bed erosion.
Crosscutting Concept	

Connections to the *Common Core State Standards* (NGAC and CCSSO 2010):

ELA	
Mathematics	

	Novice	*Emerging*	*Proficient*	*Advanced*
Claim *An explanation or conclusion that answers a research question*	*Instructional Context:* With classroom supports and modeling… Context, problem and solutions are all provided, sentence starters or cloze statements...	*Instructional Context:* When presented in isolation... Specific problems are identified, objects / events are given...	*Instructional Context:* When presented in paragraph form… Specific problems are identified, objects / events are given...	*Instructional Context:* When presented in paragraph, or auditory.. A general area of focus is provided, students are able to identify problems with teacher guidance...
Identifying / Critiquing	Student can identify the main idea of a short sentence or paragraph.	Student can identify if a statement is a fact or opinion. Student can explain / define a scientific claim.	Student will be able to identify a claim and the associated problem in appropriate grade level text.	Student will be able to critique/ evaluate a claim based on the supporting data
Constructing	Student can comment on an object, tool or solution they are presented with.	Given a problem, object or event, student can state both a fact and an opinion. Student can provide a claim about an identified problem.	Student will be able to make a claim about "the effectiveness of an object, tool, or solution that is supported by evidence". Student will develop a claim that is related to problem.	Student can make a claim about a problem, object or event and provide at least 2 substantiating data points.

	Novice	*Emerging*	*Proficient*	*Advanced*
Evidence *Data that has been collected through measurement, observation, research that pertains to a specific claim.*	*Instructional Context:* With classroom supports and modeling… Context, problem and solutions are all provided, sentence starters or cloze statements...	*Instructional Context:* When presented in isolation... Specific problems are identified, claim and evidence statements are provided….	*Instructional Context:* When presented in paragraph form… Measuring tools, graphing supports and tables have been provided...	*Instructional Context:* When presented in paragraph, or auditory.. Student chooses measuring tools, creates own tables and graphs (note not all should occur at once)...
Identifying / Critiquing	Student can identify units of measurement.	Student can identify a fact within a collection of statements.	Student can identify evidence and relate the evidence to the claim and/ the problem at hand.	Student uses the data to evaluate cause and effect, identify data that is relevant and critique data that are not.
Providing	Student can identify what type of measurement they should take in a given situation.	Student can link evidence to a claim. Student can identify what type of measurement or data collection are most appropriate.	Student can create and evaluate data to provide evidence that is related to the claim they have made. Student can take measurements using appropriate tools.	Student collects and provides evidence that supports his/her claims and can explain conflicting evidence.

`	*Novice*	*Emerging*	*Proficient*	*Advanced*
Warrant/ Justification *The justification of using the evidence to support the claim, including how the two ideas are **linked**, this encompasses the understanding of relevancy.*	*Instructional Context:* With text at student level, and limited options… Given text and relevant vocabulary choices....	*Instructional Context:* When presented in isolation... Specific problems are identified, objects / events are given, vocabulary lists are available...	*Instructional Context:* When presented in paragraph form… Specific problems are identified, objects / events are given...	*Instructional Context:* When presented in paragraph, or auditory.. A general area of focus is provided, student is able to identify problems with teacher guidance...
Identifying / Critiquing	Student can identify evidence that does not belong in a set. Student can identify justification vocabulary in a sentence.	Student can identify a statement that is used to justify the use of data to support a claim.	Student can rank provided justifications from strongest to weakest. Student actively listens to peers sharing justifications about claims.	Student can differentiate between a strong / weak justification and can verbally explain why data are not relevant to a claim.
Constructing	Student can construct a sentence to explain his/her data.	Student can verbally explain why s/he chose to use his/her data points to support his/her claim. Student can construct single written sentences that link their claim and evidence.	Student can sort their evidence into strong and weak supports to his/her claim. S/he are able to write sentences connecting evidence to the claim.	Student can give and receive critique about his/her justifications of evidence. Student can refute weak justifications and evidence.

	Novice	*Emerging*	*Proficient*	*Advanced*
Argument *The ability to use evidence to support claims made in order to persuade an audience.*	*Instructional Context:* With text at student level, and limited options… Given text, vocabulary clues, highlighting and other supportive reading strategies... .	*Instructional Context:* When presented in isolation... Specific problems are identified, objects / events are given, vocabulary lists are available...	*Instructional Context:* When presented in paragraph form… Specific problems are identified, objects / events are given...	*Instructional Context:* When presented in paragraph, or auditory.. A general area of focus is provided, students are able to identify problems with teacher guidance...
One-Sided	Student can identify claim and evidence in an argument.	Student can identify the claim, evidence, and justification in an argument. Student can identify persuasive and justification vocabulary.	Student is able to make a claim and support it with 2 or more pieces of evidence.	Student is able to make a claim, supported by evidence, and refute a counterclaim.
Two-Sided	Student can identify two sides of an argument.	Student can identify a claim and state its opposite. Student can sort provided evidence and claims to show two possible arguments.	Student can identify the two sides of an argument and identify the stronger argument based on evidence.	Student can compare and contrast two arguments, and through analyses, justify why one is stronger than the other.

Figure 1. Scientific argumentation rubric developed for second-grade students based on NGSS learning expectations.