INSTITUTE for SCIENTIST & ENGINEER EDUCATORS

Tips for constructing STEM practice rubrics

Institute for Scientist and Engineer Educators (ISEE)

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This paper was written and produced by the developers of the Professional Development Program (PDP) at the Institute for Scientist & Engineer Educators (ISEE) at University of California, Santa Cruz. The PDP was a flexible, multi-year program which trained participants to teach STEM effectively and inclusively at the post-secondary level. Participants were primarily graduate students and postdocs pursuing a broad range of science and engineering careers. Participants received training through two in-person multi-day workshops, worked on a team to collaboratively design an authentic, inclusive STEM learning experience (an “inquiry” lab), and then put their new teaching skills into practice in programs or courses, mostly at the college level. Throughout their experience, PDP participants used an array of online tools and received coaching and feedback from PDP instructors. The overall PDP experience was approximately 90 hours and was framed around three major themes: inquiry, assessment, and equity & inclusion. Leadership emerged as a fourth theme to support PDP teams, which were each led by a participant returning to the PDP for a second or third time, who gained training and a practical experience in team leadership. ISEE ran the PDP from 2001-2020, and there are more than 600 alumni.

CONTEXT FOR THIS PAPER WITHIN THE PDP

This resource was used by PDP participants to help them develop their own STEM practice rubric. It was developed over many years of observing common pitfalls as participants often struggled with creating a STEM practice rubric.

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Constructing Useful STEM Practice Rubrics

This document provides an example of a STEM practice rubric, some guidelines on creating useful practice rubrics, common pitfalls, and a list of some examples of core STEM practices.

Students often struggle with explaining results of their investigation. For example, sometimes they don't clearly state a claim, or they have a claim, and evidence to support the claim, but don't describe how the evidence supports the claim. The rubric below is a variation of "generating scientific explanations" that is focused on helping learners to articulate an explanation that has the basic components needed to be considered complete. Students and instructors used this rubric throughout an extended lab activity. In the last phase of the activity, students generated preliminary explanations and got feedback from peers (using the rubric to frame feedback), then were asked to write and hand in: their question or a hypothesis, and a concise and complete explanation of what they found.

Core STEM practice: Articulating a complete scientific explanation

Dimensions	Not yet proficient	Proficient
Claim: addresses the original question	- Does not specifically address the question - Stated in a way that is not falsifiable - Is stated as fact, rather than what can be inferred from evidence	- Stated in a way that addresses a question or hypothesis - Is falsifiable - Is reasonable scope given the evidence
Evidence: Relevant and sufficient data or observations support a claim	- Insufficient or vague evidence - Does not account for all data or results - Repeats data but does not use evidence as supporting claim	- Provides sufficient evidence - Accounts for all data/results
Reasoning: Links evidence to claim through a scientific principle or prior findings	- Only repeats evidence and/or claim - Implies the scientific principle, but does not explicitly state it - References a scientific principle but doesn't link this principle to the evidence and claim	- Cites a scientific principle or reported finding - Specifies how evidence relates to it and links it to the claim

Note on core STEM practice: This variation of "generating scientific explanations" is focused on helping learners to articulate a complete explanation. There are many other variations on generating explanations. For example, "evaluating alternative explanations."

Examples of core STEM practices: Generating research questions, defining problems hypothesizing, designing and carrying out investigations, developing and using models, building algorithms, designing solutions or processes within requirements, explaining results and/or solutions based on evidence

A useful STEM practice rubric includes:

- A focus on **one core STEM practice** (see above)**:** The core STEM practice is often made a little more specific to a context. For example, in the above rubric the core practice is "articulating a complete scientific explanation" rather than "generating explanations" or "evaluating explanations."
- Identifies a few challenging aspects (or "dimensions") of the core practice (*not* all aspects of a core practice), often stated in dimensions more as a definition
- Descriptions make each aspect assessable; at minimum describing proficiency and not yet proficient, but possibly more. Quality definitions should make it clear what an instructor would observe at various stages of proficiency with the dimension. In contrast to the dimension, the quality definition makes it clear what learners are *doing*
- All aspects of the rubric are generalizable to a different context and are **disentangled from content**

Common pitfalls in STEM practice rubrics:

- Instead of a core practice, a **skill is identified** that would be more useful if connected to a core practice. For example "interpreting graphs" would likely be more useful to learn in the context of generating explanations.
- **Dimensions add more core practices** rather than components of the focal STEM practice. It might be helpful for the team to see that they have multiple core practices, and should choose one based on what the learners will have most choice and challenge with; or which one they'll have multiple opportunities to use
- **Dimensions add other things** that the instructor wants to assess rather than components of the focal STEM practice. For example, "labeling axes of graph." This will lead to a rubric that is a variety of things, not focused on one core practice. A solution is to set aside things that are not dimensions of the practice and later consider whether they can be addressed in another way. They could be another rubric or a checklist.
- **Dimensions are not the challenging aspects of the practice:** Dimensions are fundamental, but are ultimately NOT what the learners actually struggle most with about the practice in general, or in the activity
- Descriptions **add new dimensions** rather than describing the dimensions
- Dimensions and/or quality definitions are **tangled with content.** The rubric cannot easily be applied to a different content area. Or it would be impossible for a learner struggling with content to demonstrate proficiency in the practice, according to the rubric.
- **Descriptions (or "quality definitions") have more aspects** than can be useful in practice. Participants might consider: 1) whether dimensions are actually more along the lines of a core practice; 2) the quality definitions are bringing in another core practice; or 3) whether there is a way to prioritize aspects that are the most challenging for learners or 4) whether a dimension should be split into more than one dimension
- **Practice rubric and content rubric are almost the same:** This can be challenging, but it might help to think through:
    - Content: the concept that can be used with different practices
    - Practice: the practice that can be applied in a different content area