**Appendix A**

Rubric for Lab Implementation Assessment

|  | Exemplary | Proficient | Foundational | Attempting | Lacking |
| --- | --- | --- | --- | --- | --- |
| Objective Alignment | There is clear and direct alignment between all components of the teacher’s instruction and the objective; instruction meaningfully connects the investigation to aspects of scientific literacy. | There is clear and direct alignment between all components of the teacher’s instruction and the objective. | All components of the teacher’s instruction are aligned with the objective, but alignment is loose in one or more sections. | At least one component of the teacher’s instruction is not aligned with the objective. | There is little to no alignment between the teacher’s instruction and the objective, or there is no objective. |
| Testable Question | The lab is based on a testable question (or questions) determined by students with little to no guidance from the teacher. | The lab is based on a testable question (or questions) determined by students from a list of possibilities provided by the teacher. | The lab is based on a testable question determined by the teacher with input from students. | The lab is based on a testable question determined by the teacher without input from students. | There is no testable question associated with the lab. |
| Hypothesis | Students create a scientific hypothesis (falsifiable prediction) with a strong justification; the justification includes student research beyond class materials. | Students create a scientific hypothesis (falsifiable prediction) with a strong justification (e.g., based on prior experience or a reading from class). | Students create a scientific hypothesis with a justification, but the justification is vague or implausible. | Students create a hypothesis without a justification (i.e., a guess). | Students do not create a hypothesis prior to the experiment. |
| Procedure | Students write experimental procedures, receiving support from the teacher only when they identify the need for it. | Students write experimental procedures, receiving teacher feedback at infrequent, predefined points. | The teacher provides an experimental procedure or outline of a procedure, but students have input into or can edit or add detail to procedures. | The teacher provides an experimental procedure for students to follow. | Students are not required to collect data as part of the lab (so there is no procedure to follow). |
| Data Analysis | Students use multiple distinct methods of quantitative analysis (e.g., determining the mean and % error) to analyze their data; students have input into which method of quantitative analysis should be used. | Students use one method of quantitative analysis (e.g., determining the mean and % error) to analyze their data; students have input into which method of quantitative analysis should be used. | Students use at least one method of quantitative analysis (e.g., determining the mean and % error) to analyze their data; the method of analysis is determined without student input. | Students are required to interpret data but do not use any methods of quantitative analysis to do so. | Students are not required to interpret data as part of the lab. |
| Conclusion | Students draw conclusions directly related to testable questions, support them with evidence from the lab, and identify possible sources of error and alternative explanations for the results. | Students draw conclusions directly related to testable questions, support them with evidence from the lab, and identify possible sources of error. | Students draw conclusions directly related to testable questions and support them with evidence from the lab. | Students draw conclusions directly related to testable questions but are not required to support conclusions with evidence. | Students are not required to draw conclusions related to testable questions as part of the lab. |

*Note.* For numeric scoring, exemplary corresponded to 4.0 points, proficient to 3.6 points, foundational to 3.0 points, attempting to 2.6 points, and lacking to 0 points.

**Appendix B**

Translation of Remaining Model Lab Stages to the Online Environment

**Table B1**

*Model Lab: Procedure*

|  |  |  |
| --- | --- | --- |
| In-Person Environment | Online Environment | Commentary and Tips for the Online Environment |
| * Candidates observe materials available to them for the lab (Play-Doh, different coins, buttons, washers, graduated cylinders, water, and stopwatches). * Candidates work in lab groups to write procedures in their handouts. * Instructor circulates to provide feedback and ask prompting questions. * When candidates’ procedures are complete, they raise their hands so that the instructor can sign off on the procedure. * Candidates pause within the model lab to consider the focus questions from the framing from their perspective as teachers. | * Candidates go back into breakout rooms to write procedures in their lab documents. * Instructor circulates to provide feedback and ask prompting questions. * When candidates’ procedures are complete, they click an “Ask for Help” button in the Zoom breakout room, so the instructor is alerted to enter their breakout room and sign off on the procedure. * Candidates pause within the model lab to consider the focus questions from the framing from their perspective as teachers. | Organizing and formatting materials is important in the online environment so that time can be focused on learning. For example, in our Google Doc lab templates, areas that candidates need to fill out are highlighted in yellow, and areas that require instructor sign-off to move on are highlighted in pink and have an image of a stop sign next to them. |

**Table B2**

*Model Lab: Preparing for Data Collection*

| In-Person Environment | Online Environment | Commentary and Tips for the Online Environment |
| --- | --- | --- |
| * Candidates list all the components they think should be included in a data table in their lab handouts. * Instructor projects a sample data table and takes hands for candidates to share whether they see anything in the data table that they missed in their list or whether they listed anything not included. * Candidates analyze a sample projected data table by discussing the location of key elements (e.g., independent and dependent variables) in their lab groups. * Instructor circulates to listen in to candidates’ conversations and summarizes key points for the whole group. * Candidates work in their lab groups to set up their own data tables and choose a quantitative analysis method (e.g., mean, median, or percent change) by circling at least one option from a list. * When candidates’ data tables and analysis choices are complete, they raise their hands so that the instructor can sign off and clear them to start collecting data. | * Candidates list all the components they think should be included in a data table in Nearpod using the Open Ended Question feature. * Instructor shows a sample data table on Nearpod and takes hands for candidates to share whether they see anything in the data table that they missed in their list or whether they listed anything not included. * Candidates analyze a sample data table by using the Draw It feature in Nearpod to circle key elements (e.g., independent and dependent variables). * Instructor uses Nearpod to show different candidates’ responses to the group, asking them to explain what they circled. * Candidates go into their lab groups in breakout rooms to set up their own data tables and choose a quantitative analysis method (e.g., mean, median, or percent change) by highlighting at least one option from a list. * When candidates’ data tables and analysis choices are complete, they click an “Ask for Help” button in the Zoom breakout room, so the instructor is alerted to enter their breakout room to sign off and clear them to start collecting data. | One benefit of the online environment is how much student work and thinking you can see at once as the instructor. The Open Ended and Draw It features in Nearpod both highlight this. For the Open Ended feature, the instructor can read each learner’s writing on one screen and choose to share individual entries back with the whole group. Similarly, with the Draw It feature, the instructor can see each learner’s drawing (in this case, what they circled on the data table) on one screen and choose to project any individual drawing back to the full group. Regardless of the technology tools you use, look for tools that allow you to easily see and share student work to make the most of the online environment. |

*Note.* The instruction described in this table was included in the model lab sequence to show candidates how to integrate extra support for particular lab skills as needed. The skill targeted in this case was setting up a data table.

**Table B3**

*Model Lab: Data Collection*

|  |  |  |
| --- | --- | --- |
| In-Person Environment | Online Environment | Commentary and Tips for the Online Environment |
| * Candidates collect data using physical materials. * Instructor circulates to provide feedback and ask prompting questions. * Candidates pause within the model lab to consider the focus questions from the framing from their perspective as teachers. | * Candidates collect data using the pendulum simulation in breakout rooms. * Instructor circulates to provide feedback and ask prompting questions. * Candidates pause within the model lab to consider the focus questions from the framing from their perspective as teachers. | Simulations are a great way to incorporate inquiry into the online environment. We used a PhET simulation, but there are multiple options for finding strong online simulations. Another example is SimBucket Science Simulations from PBS LearnMedia. Additionally, do not discount physical materials entirely in the online environment. In another inquiry experience online, we have students drop real things (e.g., paper, books) to investigate falling rate. |

**Table B4**

*Model Lab: Conclusion*

|  |  |  |
| --- | --- | --- |
| In-Person Environment | Online Environment | Commentary and Tips for the Online Environment |
| * Candidates write conclusions in their lab groups. * Instructor circulates to provide feedback and ask prompting questions. | * Candidates write conclusions in their lab groups in breakout rooms. * Instructor circulates to provide feedback and ask prompting questions. | Interjecting in Zoom breakout rooms as the instructor (e.g., to ask questions or provide feedback) can feel more awkward than physically circulating between groups at first. We find this awkwardness diminishes over time, but it can help to preview what this will be like for candidates before an activity begins. For example, “I’ll be popping in and out of breakout rooms. When I show up you can expect me to ask you a few questions!” |

**Table B5**

*Debriefing the Model Lab*

|  |  |  |
| --- | --- | --- |
| In-Person Environment | Online Environment | Commentary and Tips for the Online Environment |
| * Candidates discuss the focus questions from the framing as a whole group. * Candidates share ideas for using techniques they saw in the model lesson in their own classrooms at their lab tables. * Candidates score the model lab on the assessment rubric; they read one rubric item at a time and hold up a number of fingers to correspond to the score they would give the model lab. The instructor calls on candidates to provide rationale and evidence for their scores. | * Candidates discuss the focus questions from the framing as a whole group. * Candidates share ideas for using techniques they saw in the model lesson in their own classrooms in small groups in breakout rooms. These groups can be different from their lab groups so that candidates can interact with more peers in the small-group environment. * Candidates score the model lab on the assessment rubric; they read one rubric item at a time and hold up a number of fingers to correspond to the score they would give the model lab. The instructor calls on candidates to provide rationale and evidence for their scores. | Whole-group discussions on Zoom can, like interjecting in breakout rooms, feel a little awkward at first. Provide some guidance for learners to set them up for success. For example, “I’m going to mute myself and I’d like to hear from three or four of you on our first focus question. If two of you unmute at once, that’s ok—whoever shares first can call on the other person next.” Additionally, mixing small- and whole-group discussions can help maintain engagement while giving everyone the chance to participate frequently. The online environment also allows you to keep small groups the same for sustained work over time, as with the lab groups in this example, or mix up the small groups so candidates can interact with a wider variety of peers, as in this debrief. |