Rubrics for Assessing Hands-On Laboratory Skills

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ABSTRACT: This communication shares with the chemistry education community the rubrics used to evaluate student videos associated with using a pipet, using a buret, and making a solution in a volumetric flask that were part of a digital badging project. The rubrics were used across multiple general chemistry courses, hundreds of teaching assistants, and thousands of students. Guidelines for implementation of the rubrics, including the training of teaching assistants or groups of graders, are provided.

KEYWORDS: High School/Introductory Chemistry, First-Year Undergraduate/General, Laboratory Instruction, Hands-On Learning/Manipulatives, Laboratory Equipment/Apparatus

The purpose of this communication is to share with the chemical education community rubrics associated with our work in a digital badging project.1–3 Previously, we have published research related to the efficacy of digital badging activities in improving student hands-on learning of laboratory skills. This communication extends this work and provides more tools for faculty interested in assessing student hands-on skills. The rubrics are contained in the Supporting Information for this article, and herein, we briefly introduce rubrics and describe the development and implementation of our rubrics.

WHAT IS A RUBRIC?

A rubric is a set of criteria for student work that includes descriptive statements associated with levels of performance.4–7 A carefully constructed rubric clarifies and communicates expectations to students, especially if they have access to the rubric while completing an assignment, task, or project. Additionally, rubrics support consistency in assessing and grading assignments across students in a section and in a course. Rubrics also help faculty and teaching assistants provide feedback that is targeted and aligned to the criteria associated with an assignment.

Rubrics have been in use in the United States for decades. Perhaps the most widely known in higher education are the American Association of Colleges and Universities VALUE Rubrics (AACU) that were developed as part of the AACU’s Liberal Education and America’s Promise initiative.8 These rubrics cover 16 learning outcomes and extend across the undergraduate educational experience.

In this Journal, rubrics have a history of being developed and disseminated to improve assessment of students’ performance in a variety of areas including experimental problem solving,9 experimental skills in organic chemistry,10 critical thinking,11 high school chemistry lab skills,12 and process skills.13–15 Additionally, there are rubrics that can guide curriculum development in POGIL (Process oriented guided inquiry learning) that have been published.16

DEVELOPMENT AND IMPLEMENTATION

The rubrics shared in the Supporting Information were developed as part of our digital badging project. These rubrics were aligned with the performance criteria contained in the previously published articles.1–3 They were implemented beginning in 2016 and have been used with over 8,000 students and nearly 300 teaching assistants. Utilization of these rubrics by a large assortment of teaching assistants across multiple courses allowed us to obtain valuable feedback that we used to refine the rubrics. We also had the opportunity to obtain feedback from students about the usefulness and clarity of the rubrics in the evaluation of their performance.

In terms of implementation, we note that training of faculty and teaching assistants will lead to greater consistency in applying the rubric for assessment purposes. One way this can be achieved is by having instructors (or teaching assistants) use a rubric to evaluate a series of sample videos and to discuss the evaluations, especially areas of disagreement. This activity will help faculty and teaching assistants provide feedback that is targeted and aligned to the criteria associated with an assignment.

We also note that faculty can define a passing score when using these rubrics. In our implementation, we allowed students to achieve less than full marks and receive a digital badge for successful use of that piece of equipment. The criteria associated with not receiving a badge were chosen because they represented either a safety hazard or a completely invalid measurement. For example, if a student used a beaker to fill a buret and reached above his or her head to pour the liquid into the buret rather than lowering the buret to an appropriate height and using a funnel, this would result in the student being denied a badge because it represents a safety
hazard. The student would receive targeted feedback and be asked to revise and resubmit the video. In cases where the student is denied a badge, it is important to provide feedback that allows the student to revise and improve his or her performance so that the ultimate result is correct and safe use of the equipment as well as the awarding of a digital badge.

Although we developed these rubrics as part of our badging project, we share them with the chemistry community in the hope that they can be adapted and implemented in conjunction with the assessment needs and contexts of individual departments and instructors. For example, these rubrics could be implemented as a peer review activity where students evaluate each other’s work, which has been demonstrated to positively impact student learning.\(^{17,18}\) In fact, this is how Seery and co-workers operationalize the rubrics used in their digital badging project.\(^{12,19,20}\) Implementing the rubrics in this manner may provide students with an opportunity to act on feedback from peers and to adopt an evaluative stance in considering another student’s performance that in turn influences his or her own work and learning.

There has been a persistent call initiated by Hofstein and Lunetta\(^{21,22}\) and more recently by Bretz\(^{23}\) in 2019 to collect laboratory provides evidence of a student's hands-on skills and is a more authentic and direct measure of these skills than a written report. Sharing rubrics from our badging project allows faculty to more authentically assess the students’ ability to safely and correctly use equipment in laboratory. We hope that faculty find these rubrics useful, and we welcome questions and comments through email, and at presentations and workshops.

### ASSOCIATED CONTENT

**Supporting Information**

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.0c00200.

Rubrics for the pipet, buret, and volumetric flask digital badge (PDF, DOCX)

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**Notes**

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### REFERENCES


