Rubrics are learning tools for students and teachers. They can be used to clarify learning goals, provide feedback, and improve critical thinking. However, is not enough to achieve learning gains (NRC 2001). Using the rubric as a tool—not just a measuring stick—is the key to reaping the full benefits it has to offer.

In this article, we describe a series of rubrics developed for our general and advanced biology courses. We then develop three ideas, based on the science education literature and our own experience, for using rubrics to foster learning—to clarify learning goals, build complex understandings, and encourage intellectual risk-taking.

**“Stem Cells: You Decide” Rubric**

We developed the “Stem Cells: You Decide” rubric for a biotechnology paper that included independent internet research on stem cells. Students selected a topic from a list of controversies, including:

- Using adult stem cells to treat a specific disease,
- Using somatic cell nuclear transfer to produce embryonic stem cells, or

**More information on stem cells.**

- Stem cells are undifferentiated cells that have the ability to divide indefinitely.
- Adult stem cells are multipotent—they can produce specialized cells for the tissue in which they are found; they are found in specific tissues from birth on.
- Embryonic stem cells are pluripotent—they can produce any cell type in the body. They are isolated from blastocysts; the isolation process destroys the blastocyst.
- Blastocysts are early-stage (four to five days after fertilization) embryos.
- In vitro fertilization (IVF) is the process of joining an egg and sperm outside of the body, leading to the
production of an embryo. These embryos are derived during fertility treatment. Embryos remaining after in vitro fertilization fertility treatment may be used to isolate embryonic stem cells. The isolation of these cells destroys the blastocyst. This process has been successful in animals and humans.

- Somatic cell nuclear transfer (SCNT) is a process in which the nucleus of a somatic cell (e.g., skin cell) is transferred into an egg cell that has had its nucleus removed. The resulting cell is embryo-like and is genetically identical to the somatic cell donor. If the embryo develops to the blastocyst stage, embryonic stem cells can be isolated and used for patient-specific therapy and disease treatment. This process has been successful in animals, but has not yet been accomplished in humans.

Students then browsed websites on their chosen topics, analyzed the information provided by these websites, and made a decision about the topic based on their analysis and prior knowledge (Figure 1, p. 30).

We developed the rubric for this assignment over time. First, we created a detailed checklist to spell out the criteria for each part of the paper. The difference between a checklist and a rubric is that a rubric has defined levels of quality; checklists, on the other hand, contain no judgment of quality—items are simply present or not (Quinlan 2006).

After working with the checklist, we realized that we needed more detail, so we used examples of student work to develop a rubric. We sorted work into high, medium, and low categories, which helped us describe varying levels of performance. The result was a task-specific rubric that specified scoring levels for each component of the paper (Figure 2, p. 31). Because the task-specific rubric is so detailed, it can be tedious to use compared to a generic rubric (Figure 3, p. 32) — which judges the overall quality of a performance or product (see "Types of rubrics," p. 30). However, we found the task-specific rubric helpful for this type of assignment.
Types of rubrics.
- Checklist: A checklist is not a rubric—because there are no levels of performance specified—but it does provide criteria students should address.
- Task-specific rubric: This type of rubric is detailed for each component of an assignment. Task-specific rubrics can be helpful for grading complex questions, but cannot be used repeatedly because they are targeted for a particular assignment.
- Generic rubric: This type of rubric can be used with more than one assessment. It is powerful because it can be applied to many assessments and help students learn what “high quality” work should look like (Siegel et al. 2006; Wiggins 1998).

"Stem Cells: You Decide" assignment.

Over the course of a month, students developed the four sections of their papers in four different stages (see Halverson, Siegel, and Freyermuth 2009 for details):

1. The introduction and science background material.
2. A description of the controversy and multiple viewpoints.
3. A critique of the websites used.
4. Their personal, evidence-based opinions on the controversy.

For the critique portion of the assignment, we provided students with prompts, including:

- Do any of the websites leave out critical information about the topic?
- Does the person or organization responsible for the material have a mission statement listed on the website? Is it clear why they are supplying this information?
- Are there inconsistencies in the information reported?
- Are there statements that show the bias of the website? Are these statements accurate?

After all stages were complete, and students compiled each section into complete drafts of their papers, they exchanged them for peer review. Students used the provided rubric (Figure 2) and the following prompts to review one another's work:

- Do you understand the science as the student-author describes it?
- Do you understand the controversies?
- Does the student-author do a sufficient job of analyzing his or her website references?
- Does the student-author thoroughly explain his or her personal opinion and reasons for it?

(Notes: Many helpful rubric templates are available in books [e.g., Stevens and Levi 2004] and online [see Rubistar “On the web” at the end of this article].)

"Evolution" rubric

We created another task-specific rubric for our advanced biology course. The “Evolution” assignment required students to write a four-page scientific argument providing evidence for evolution and how this idea has shaped the way biology is currently studied. We gave each student a copy of this rubric (see “On the web”) with the assignment.

For this paper, students had to review primary literature, such as the journal Evolution, for sources of evidence (instead of websites). We required students to use at least three “current” sources, published in 2000 or later, and to write for an audience of somewhat scientifically literate individuals debating the authenticity of evolution. Students also reviewed editorials from scientific journals to better understand the expected style. We encouraged them to use database searches (e.g., JSTOR, ERIC) to identify and obtain these primary resources.

Students then had two weeks to write their first drafts and bring them to class for peer review. Each student reviewed another student’s paper using the task-specific rubric. They made comments based on the rubric guidelines and wrote a summative section to highlight the paper’s perceived strengths and weaknesses. After the written feedback was completed, the reviewer and author paired up to discuss comments and suggestions. Students said that this process helped strengthen their papers.

After completing the peer reviews, students had one week to revise their papers and submit a second draft. This time, we provided a second round of feedback using the rubric. Based on this feedback, students were allowed to complete a final rewrite of their papers. These final versions were collected and evaluated based on the task-specific rubric we provided at the beginning of the assignment. (Note: This task-specific rubric is available online [see “On the web”].)

More than grading

The benefits of using rubrics for grading purposes are well-known, but the lesser-known benefits go beyond simply grading. For example, rubrics can be used to clarify learning goals, build complex understandings, and encourage intellectual risk-taking. We have
found evidence of these benefits in the science education literature and through our own experience.

Clarifying learning goals
Being explicit about learning objectives by providing rubrics at the beginning of a course or project helps students take control of their learning. Research has shown that using assessments to make learning objectives explicit enhances learning (William et al. 2004). For example, we explain the Stem Cells: You Decide rubric by providing detail about each criterion. We show students examples of work at various levels of the rubric (e.g., novice, developing, accomplished) and explain why they fit into one level or another.

![FIGURE 2](image-url)

"Stem Cells: You Decide": Task-specific rubric.

<table>
<thead>
<tr>
<th>Name: ________________________________</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Background</th>
<th>Novice</th>
<th>Developing</th>
<th>Accomplished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper is not introduced well, or contains major inaccuracies.</td>
<td>(0–4 points)</td>
<td>Introduction does not mesh with rest of paper, or has minor inaccuracies.</td>
<td>(5–7 points)</td>
</tr>
<tr>
<td>Alternative opinions are irrelevant or inaccurate.</td>
<td>(0–2 points)</td>
<td>Alternative opinions contain some minor flaws.</td>
<td>(3–4 points)</td>
</tr>
<tr>
<td>Content is inaccurate, irrelevant, or repetitive, and contains questionable evidence.</td>
<td>(0–10 points)</td>
<td>Content has minor flaws or is not elaborated. Less than four statements address the critique for each website.</td>
<td>(11–14 points)</td>
</tr>
<tr>
<td>Student provides little accurate support for choice.</td>
<td>(0–7 points)</td>
<td>Student makes a choice, but it is not well supported.</td>
<td>(8–10 points)</td>
</tr>
<tr>
<td>Reference list contains two or less (viable) websites. Citations are incomplete within the reference list or text.</td>
<td>(0–2 points)</td>
<td>Reference list contains three to four (viable) websites. Correct in-text citations are included in the body of the paper.</td>
<td>(3–4 points)</td>
</tr>
<tr>
<td>Reference list contains more than four (viable) websites with full citation (e.g., author, title, date, link). Correct in-text citations are included in the body of the paper.</td>
<td>(5 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper has major clarity, organization, coherence, or grammatical issues.</td>
<td>(0–4 points)</td>
<td>Paper has minor clarity, organization, coherence, or grammatical issues.</td>
<td>(5–7 points)</td>
</tr>
<tr>
<td>Paper is coherent and clearly written, with few grammatical or spelling errors.</td>
<td>(8–10 points)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total points: __/60
The learning goals are represented in the rubric’s criteria. For example, with the Evolution rubric (see “On the web”), students learn how to make valid claims that support an argument. The teacher can explain what a valid claim is or which argument the rubric is referring to, but for students to thoroughly understand the learning goals, they must use the rubric themselves.

One idea is to have students rewrite the rubric in their own words. This can be especially helpful if the rubric is terminology-heavy. Another strategy is to have students self-evaluate or peer-evaluate their work. Using the Evolution and Stem Cells: You Decide rubrics, students peer reviewed one another’s drafts and provided one-on-one feedback. This helped students understand the expectations outlined in the rubric.

In one study, researchers found that training middle school students to grade their own work with a rubric resulted in excellent understanding of the objectives it outlined, as shown by high correlations between student and teacher rubric grades on test questions ($r = 0.91$ to $0.94$) (Sadler and Good 2006). Studies have also shown that self-assessment, as completed through the revision process using rubrics, improves student achievement—especially with low-performing students (Black and Wiliam 1998).

**Building complex understandings**

The most common type of rubric for a particular project or assignment is the task-specific rubric. This rubric can be effective for building conceptual understanding, as in the Stem Cells: You Decide assignment. While gauging students’ understanding, we administered a pretest and posttest about stem cells and stem cell research. Students showed significant improvement of overall understanding on the posttest—and 10 different misconceptions were addressed (Concannon et al. 2010; Halverson et al., forthcoming). Students learned, for example, that adult stem cells exist in infants.

The advantage of a generic rubric—compared to a task-specific one—is that it can be used many times for different assignments to reinforce major learning goals. Generic rubrics can be applied to different types of projects and help students learn how “high quality” is defined (Siegel et al. 2006; Wiggins 1998). For example, consider a major learning goal that all students should master by the end of the course, such as rigorously analyzing data or effectively designing an experiment. By providing a rubric with these goals and repeatedly using it to assess multiple types of work, students have more opportunities to learn and reinforce these skills.

And research is beginning to indicate that using generic
rubrics appropriately over a semester or full-year course can stimulate student learning (Siegel et al. 2006).

Using a hybrid rubric allows teachers to reap the benefits of each type. This kind of rubric includes some generic criteria, such as major learning goals that are included on all rubrics throughout the year, and some task-specific criteria that relate specifically to the learning goals of a particular task.

Encouraging intellectual risk-taking

As students begin to expect rubrics in their courses, new challenges arise. Occasionally, they might perform only the minimal amount of work needed to meet the criteria, rather than striving for greater intellectual achievement.

One way to counter this problem is to add an extra performance level. Consider a rubric with three levels (e.g., Arter and McTighe 2001; Siegel et al. 2006)—the third is “accomplished” and describes the performance a teacher expects for the highest grade. For making a scientific argument, for example, the rubric might read, “Level 3: Provides appropriate information to make a claim, good use of examples and counter examples, and concise explanations.”

A fourth level—called “beyond expectations”—could be added to this rubric. To achieve this level, students would need to accomplish Level 3 and add a significant component to their argument. Level 4 might be described as, “Exceeds expectations in a significant way; for example, questions the validity of the data.”

This rubric provides clear expectations of student achievement to receive a top grade (Level 3), but also challenges students to come up with other ways to improve their arguments (Level 4). Teachers can choose to provide a grading incentive for Level 4 responses, such as extra credit points, or take attainment of Level 4 into consideration if a student’s final grade is close to the next grade boundary.

Another way to foster higher-level thinking is to require students to reflect on their learning. For the Stem Cells: You Decide and Evolution assignments, for example, students can be asked what they have learned about themselves and how scientific research is affected and mediated by society. The quality of this reflection can be added to the rubric. Additional expectation levels, such as these, encourage students to reach for intellectual goals instead of grades.

Conclusion

Rubrics can help students take control of the learning process, build complex understanding of the material, and take intellectual risks. Like any educational tool, simply adding a rubric to instruction is not enough. Rubrics must be part of the fabric of the class, in such a way that the philosophy of enhanced learning is brought to life.

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On the web

Rubistar: www.rubistar.4teachers.org

References
