

A Rubric-based Assessment of Student Mastery of Learning-Based Outcomes in a General Microbiology Course

Rachel M. Watson

Methods

In order to assess student learning in General Microbiology, a list of learning outcomes appropriate to the class was first solidified. These learning outcomes interweave/adapt the current learning outcomes of the Molecular Biology Department and Biology Core Curriculum with the outcomes that I find important as the current instructor of General Microbiology.

<i>Investigation</i>	<p>Students completing all aspects of Microbiology will be able to: (understand and apply the scientific method)</p> <ul style="list-style-type: none"> - access both public perspective and scientific literature, broadcasts and podcasts - Understand different types of hypotheses - Formulate / propose hypotheses - monitor and evaluate events as they occur within the larger scientific world - propose experimental tests of hypotheses - apply appropriate experimental methods to test hypotheses - make and interpret observations and relate them to the hypothesis - understand basic laboratory etiquette
<i>Critical Thought</i>	<p>Students completing all aspects of Microbiology will be able to:</p> <ul style="list-style-type: none"> - summarize / retain important points from a lecture or reading within the microbiology field - perform a thorough overview of a topic without being overwhelmed by extent of available literature - assess public perspective and scientific literature as well as broadcasts, podcasts and lectures - recognize bias / author standpoint - recognize science as something done by people and not divorced of personal interests
<i>Communication</i>	<p>Students completing all aspects of Microbiology will be able to:</p> <ul style="list-style-type: none"> - present, write or converse using the vocabulary of the field (communicate effectively with those in the field) - communicate important principles with a non-scientist - Understand the basic structure / organization of writing a scientific paper, notebook or abstract - Understand when and how to reference source material and recognize this process as an important part of communicating with other scholars - Write, converse or present clearly and thoroughly - Recognize that the modern scientific voice is an active voice
<i>Synthesis</i>	<p>Students completing all aspects of microbiology will be able to:</p> <ul style="list-style-type: none"> - relate (recognize relevance of) concepts to other disciplines and to life - understand the social ramifications (social perceptions), applications and implications of scientific actions / studies - value scientific knowledge as a tool to enact change (be aware of the limits to this and responsibility inherent with this)

Although every effort has always been made to teach General Microbiology students with these learning outcomes in mind, this semester rubric-based assessment was implemented in attempt to document student progress. Assessment was implemented around a semester-long research project in which student groups identify a current topic, propose a hypothesis, write an abstract and present their findings in poster format. For a full description of the assignment please see the course web site: http://www.uwyo.edu/molb2210_lect/lecture/info.html. Although this assignment ultimately addressed nearly every proposed learning outcome, this semester assessment was performed for the processes of hypothesis development and abstract writing only. The following rubric was designed to assess hypotheses:

Hypothesis	Satisfactory	Unsatisfactory
is either observational and predictive or manipulated	<i>Reflects a clear reading of assignment description and is phrased as either a prediction or if, then statement</i>	<i>Understanding of assignment description is insufficient to enable a clearly phrased hypothesis of either type.</i>
is narrow in scope (not too broad)	<i>A thorough overview addressing the hypothesis can be accomplished during the course of the semester</i>	<i>The research required to competently address the hypothesis during the course of the semester would be difficult to impossible.</i>
is grounded in background knowledge	<i>Reflects sufficient preliminary investigation to allow for formulation of hypothesis</i>	<i>Preliminary investigation was insufficient to allow for an educated prediction / or prediction doesn't reflect research</i>
can be tested	<i>During the course of the semester, it will be possible to support, accept, reject, modify or disprove the hypothesis.</i>	<i>It will be impossible to support, accept, reject, modify or disprove the hypothesis during the course of the semester.</i>
states clearly the predicted results (changes/outcomes)	<i>A time frame and prediction of what will happen in that time frame is specified.</i>	<i>Prediction either lacks a specified time frame or events that will occur are not specified.</i>

This rubric addresses many of the learning outcomes, including but not necessarily limited to: accessing literature, understanding different types of and formulating hypotheses, understanding applications and implications of science, writing clearly using the vocabulary of the discipline and retaining important points from reading. In order to assess mastery using the above rubric, students submitted an initial hypothesis that was written with no coaching. Upon receiving this hypothesis, each category was assessed by the instructor as either satisfactory or unsatisfactory. Students were then given coaching as to how to improve their work before being asked to resubmit the hypothesis. Second and sometimes third attempts were assessed for mastery. Attempts were limited only by time; No further changes were assessed after the first due date for the abstract. Following is an example of an initial hypothesis, the feedback given to student groups between attempts, and the final hypothesis. This group improved from being assessed with all categories rating Unsatisfactory to all categories rating Satisfactory:

Initial hypothesis:

We predict that based on the tendencies of how MRSA spreads, prevention and awareness will increase specifically within the football community.

Feedback:

I think that the hypothesis that you're heading towards is a manipulated hypothesis of sorts. That is, I think it would be best addressed with an if / then statement. So, for example: If MRSA continues to spread, then ... But even before you make that statement, you'll want to be certain (perhaps by finding stats on cdc.gov) that MRSA is indeed spreading. If you do find this info. then you may start with a quick sentence that says something about the spread. This would show your reader that the prediction that you're about to make is grounded in knowledge (i.e. Based on the most recent data from the Centers for Disease Control and Prevention, MRSA is spreading more rapidly through college football players than it has in previous years. Thus, we predict that if this spread continues, then....) Next, for the second part of your prediction, you'll want to be wary of terms like prevention and awareness will increase. How can we test this. We need to have some sort of marker, something that proves that prevention and awareness have increased. (e.g. Based on the most recent data from the Centers for Disease Control and Prevention, MRSA is spreading more rapidly through college football players than it has in previous years. Thus, we predict that if this spread continues, then an NCAA statute will be put into place requiring that all football players take a course about the prevention of MRSA). Now, please note that I completely made up the above examples, you'll have to do a bit more research to determine what would be most appropriate. But, I hope this helps you with the overall format and testability of your prediction.

Final hypothesis:

Based on a study done by Carolyn Rogers for the American Academy of Orthopaedic Surgeons, during the University of Southern California's 2003 football season 17 of the 107 players on the team presented with MRSA-like infections (all requiring surgical incision and drainage); eleven players were later confirmed as being infected with MRSA, and 6 of the 11 were hospitalized. The effectiveness of the infection control measures implemented by USC can be seen in the marked decrease in MRSA infections; only one player was found to have an infection caused by MRSA that year. Thus, we predict that if the infection control measures implemented by USC are implemented by other division I football teams, then the amount of MRSA infections within the division I football community will decrease within a year of incorporating such precautions.

A similar rubric was designed for assessment of abstracts:

Abstract	Satisfactory	Unsatisfactory
The abstract reflects ability to access public perspective and journal articles	<i>It is clear that the students accessed source material of both types</i>	<i>Students either failed to access source material of either or both types or it is not evident</i>
The abstract reflects ability to assess public perspective and journal articles	<i>Abstract reflects critical thinking about / evaluation of the source material.</i>	<i>Either critical thinking / evaluation of source material was not done or it is not evident</i>
The abstract includes all important components: background, statement of purpose/hypothesis, methods, pertinent findings, hypothesis accepted/rejected, conclusion	<i>All are included</i>	<i>Some are lacking</i>
The abstract reflects ability to relate pertinent findings to hypothesis	<i>A link between research findings and prediction is evident</i>	<i>Either there is no evident link between research findings and hypothesis or link is tenuous.</i>
The abstract reflects a thorough overview of the available literature (appropriate to the topic)	<i>Abstract seems to reflect an appropriate variety of sources</i>	<i>Diversity in source material is not evident</i>
The abstract is clear / concise	<i>Easy to read / follow</i>	<i>Could be easier to read / follow</i>
The abstract is written without citations (correct)	<i>No citations included</i>	<i>Citations included</i>
The abstract is written as a single paragraph	<i>Single paragraph</i>	<i>Multiple paragraphs or no cohesive paragraph evident</i>
The abstract reflects an understanding (appropriate to the level) of the topic	<i>understanding apparent</i>	<i>Understanding is lacking or not evident in writing of abstract</i>

This rubric addresses nearly all of the remaining learning outcomes including but not limited to: accessing and assessing public perspective and scientific literature, monitoring and evaluating events as they occur within the larger scientific world, applying appropriate methods to test hypotheses, making and interpreting observations as they apply to hypotheses, performing a thorough overview of the literature, writing using the vocabulary of the field, communicating important points to nonscientists, and understanding the basic structure of an abstract. Students first submitted an initial draft of their abstract based on the instructions given in the assignment description. Upon receiving the initial draft, the instructor edited and made helpful comments on the documents using the Track Changes and Insert Comments features in Word. Students then submitted a second and possibly third version that was assessed for mastery. Again, the only limitation to resubmission was time. Abstract edits were no longer accepted after the final abstract packet had been written.

Results

Table 1

Hypothesis	Percentage of student groups mastering outcome on initial submission (N=15)	Percentage of student groups mastering outcome on final submission (N=15)
is either observational and predictive or manipulated	33	87
is narrow in scope (not too broad)	33	80
is grounded in background knowledge	40	87
can be tested	13	67
states clearly the predicted results (changes/outcomes)	20	73

As can be seen (Table 1) less than half of the student groups mastered the hypothesis components on the first attempt. However, in all cases, a majority of the student groups mastered these skills on the final submission. On their initial attempt, the fewest number of student groups mastered the skill of making their hypothesis testable. Even on the final attempt this was the least mastered skill. The greatest percentage improvement was seen in students' abilities to formulate the hypothesis as suggested in the assignment description.

Table 2

Abstract	Percentage of student groups mastering outcome on initial submission (N=15)	Percentage of student groups mastering outcome on final submission (N=15)
The abstract reflects ability to access public perspective and journal articles	60	80
The abstract reflects ability to assess public perspective and journal articles	80	100
The abstract includes all important components: background, statement of purpose/hypothesis, methods, pertinent findings, hypothesis accepted/rejected, conclusion	27	73
The abstract reflects ability to relate pertinent findings to hypothesis	33	87
The abstract reflects a thorough overview of the available literature (appropriate to the topic)	40	73
The abstract is clear / concise	53	73
The abstract is written without citations (correct)	73	100
The abstract is written as a single paragraph	87	93
The abstract reflects an understanding (appropriate to the level) of the topic	93	93

More than half of the student groups mastered six of the outcomes on the first attempt (Table 2). A majority of student groups mastered all of the outcomes on the final attempt. On the initial attempt, the inclusion of all components of an abstract was the least mastered outcome. This, along with clear, concise writing and ability to present a thorough overview of the topic, were the least mastered skills on the final attempt. In all but one category, reflection of knowledge, student groups showed an improvement in mastery from the initial to final submission. The greatest percentage improvement was seen in students' abilities to relate pertinent findings to the hypothesis.

Discussion

On a positive note, it can be concluded that a majority of student groups mastered all of the rubric-assessed skills. In terms of generating a hypothesis, students struggled the most with creating a prediction that could be tested. This could be due, in part, to the fact that this requires not only knowledge of what needs to be done but the skill of being able to determine what types of statements can be supported / disproved. This contrasts greatly to the most improved skill, generating a hypothesis of the format described by the assignment, which requires only following directions and mimicking examples.

The fact that more than half of the student groups showed mastery of six of the abstract categories on the initial attempt might be partially reflective of thoroughness of the assignment description. Alternatively, students may have become more familiar with assessment methods by this later submission date. In challenge to the former explanation is the very low percentage (27%) of student groups including, on their first attempt, all components of the abstract as outlined in the assignment description. The very high percent (93%) of student groups reflecting an understanding of their topic on the initial attempt of the abstract is encouraging and perhaps reflects the benefit of a semester-long project for which student have already had to learn a lot in order to submit a copasetic hypothesis. Student improvement from the initial to final abstract attempt was positive. The one exception, the percentage of student groups mastering reflection of topic knowledge in their abstract, may be explained by the fact that repeated attempts, even with coaching, do not take the place of time spent researching (self-teaching).

Personal reflections of advantages and lessons learned:

For me, the best part of rubric-based assessment was that it kept my work honest and consistent. It kept me from forgetting to look for particular qualities in students' work. In the end this benefited them the most because I was more likely to push groups whose high quality of work may have, in previous semesters, caused me to perform a more cursory assessment. This type of assessment also forced me to see learning as a process and a process in which both the instructor and the student play a role. The more time I was willing to invest, the more learning the students were able to do.

Although most of the advantages seem to be in enhancing the quality of the process, I was struck by the benefits of quantization as it made apparent that which I wouldn't have noticed otherwise. For example, it was only after crunching the numbers that I realized that students struggled the most with formulating a hypothesis that could be tested. Now that I am aware of this I can focus my assistance toward that outcome.

For future semesters there are a few changes that I may make to the rubrics. Likely because of my experience in designing the hypothesis assessment rubric first, the abstract assessment rubric seems to need less change. Many of these changes are deletions of outcomes that are already encompassed elsewhere. Some of them are splits

because I was attempting to assess two outcomes at once, which obviously was not effective. These changes are detailed in the rubrics below:

Hypothesis	Satisfactory	Unsatisfactory
is either observational and predictive or manipulated	<i>Reflects a clear reading of assignment description and Hypothesis is phrased as either a prediction or if, then statement</i>	<i>.Understanding of assignment description is insufficient to enable a clearly phrased hypothesis of either type. Hypothesis is neither phrased as prediction or if, then statement</i>
is narrow in scope (not too broad)	<i>A thorough overview addressing the hypothesis can be accomplished during the course of the semester</i>	<i>The research required to competently address the hypothesis during the course of the semester would be difficult to impossible.</i>
is grounded in background knowledge	<i>Reflects sufficient preliminary investigation to allow for formulation of hypothesis</i>	<i>Preliminary investigation was insufficient to allow for an educated prediction / or prediction doesn't reflect research</i>
can be tested	<i>During the course of the semester, it will be possible to support, accept, reject, modify or disprove the hypothesis.</i>	<i>It will be impossible to support, accept, reject, modify or disprove the hypothesis during the course of the semester.</i>
states clearly the predicted results (changes/outcomes)	<i>A time frame and prediction of what will happen in that time frame is specified. Changes/outcomes are specified</i>	<i>Prediction either lacks a specified time frame or events that will occur are not specified. Changes/outcomes are not specified or are not clear</i>

Abstract	Satisfactory	Unsatisfactory
The abstract reflects ability to access public perspective and journal articles	<i>It is clear that the students accessed source material of both types</i>	<i>Students either failed to access source material of either or both types or it is not evident</i>
The abstract reflects ability to assess public perspective and journal articles	<i>Abstracts reflects critical thinking about / evaluation of the source material.</i>	<i>Either critical thinking / evaluation of source material was not done or it is not evident</i>
The abstract includes all important components: background, statement of purpose/hypothesis, methods, pertinent findings, hypothesis accepted/rejected, conclusion	<i>All are included</i>	<i>Some are lacking</i>
The abstract reflects ability to relate pertinent findings to hypothesis	<i>A link between research findings and prediction is evident</i>	<i>Either there is no evident link between research findings and hypothesis or link is tenuous.</i>
The abstract reflects a thorough overview of the available literature (appropriate to the topic)	<i>Abstract seems to reflect an appropriate variety of sources</i>	<i>Diversity in source material is not evident</i>
The abstract is clear / concise	<i>Easy to read / follow</i>	<i>Could be easier to read / follow</i>
The abstract is concise	<i>Appropriate length (usually ~300 to 350 words)</i>	<i>Very wordy / not wordy enough</i>
The abstract is written without citations (correct)	<i>No citations included</i>	<i>Citations included</i>
The abstract is written as a single paragraph	<i>Single paragraph</i>	<i>Multiple paragraphs or no cohesive paragraph evident</i>
The abstract reflects an understanding (appropriate to the level) of the topic	<i>Understanding apparent</i>	<i>Understanding is lacking or not evident in writing of abstract</i>