Assessing Complex Behaviours: Improving Student Writing Skills Using a "A Short Guide to Writing about Biology" and Marking Rubrics

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Expanded Abstract

At the ABLE 2003 meeting, my workshop wasn't a "how to" kind of talk which lends itself to a logical way to present the information in a write-up. Let me start with an apology. This space will serve for me to open a dialogue, and I won't be able to tell you how to solve the problem of improving student writing. This is a sort of "stream of consciousness" presentation and I'll try to get you to understand my motivations and show you how I attempted to address the issue. I've added the first three words to the title, to reflect what in the end I'm trying to do. If you're swayed by my ideas and wish to talk further, email me at *tnickle@mtroyal.ca*. If you think I'm misguided, I welcome your ideas too! I think my intentions are good, but too often are colleagues timid to call out one of their own. I assure you, I'm more interested in improving my craft than I am in defending how I'm currently doing it.

At a recent campus-wide professional development workshop, it became apparent to me that most students are becoming less reliant on printed media. Though textbooks will not go away in the near future, I suspect they're morphing into a vestigial appendage – at least as far as some students are concerned – and aren't being used effectively. I began to wonder if perhaps the books were not used because student comprehension of text is becoming lower due to disuse? When instructors queried students about the last time they had to write a complex piece of work, many found that a majority of students hadn't written anything resembling an essay since the early years of High

School. Overcrowded classrooms, understaffed schools, and high teaching loads have crushed Alberta teachers for over a decade, and time for instructors to read complex student work and provide adequate feedback has all but disappeared. Where assessment is concerned, students often are given "blue sky" grades and comments. Without being held responsible and given appropriate feedback on their writing, students become less attentive and critical of the writing of others and tend to "wait for the movie version" (in a large number of course textbooks, this would be the animations on the CD-ROM). I decided to make the laboratory activities focus students on relating their findings and ideas according to clearly stated criteria found in Jan Pechenik's "A Short Guide to Writing About Biology."

I started with the question "What can your students DO when they leave this course?" Granted, it's wonderful if they can apply the terms hypotonic and hypertonic appropriately and pick out labels on a foot-high model of a cell. As RuthAnne Pitkin pointed out at ABLE 2002, the practical skills are what justify the high cost of having students actually touch a living specimen in a life sciences course. I decided the most important thing they can DO is *tell you what they did* in a clear and effective manner. Students who will not continue in biological courses will benefit by improving their abilities to communicate well, and biology majors will be launched on their journey to describe simply and clearly the muddy and complex milieu surrounding any living thing.

I decided to follow the laboratory model put forward by Kevin Piers at ABLE 2002: I used the PI lab format (see p. 334 in the Proceedings of the 24th ABLE Workshop/Conference). In a nutshell, this has students design and perform their own experiment and review each other's work to create the best possible manuscript of their findings. The process mirrors the "real world" activities of the typical lab run by a PI (primary investigator) and assistants, as well as having the final product run past peer reviewers (who in this case aren't anonymous as they are in the professional realm).

The task of creating a good experiment is difficult. Students must try to anticipate all the things that will be required to run it (as opposed to simply following instructions such as "place the leaf into the supplied petri dish and cover it with the 10" square of aluminum foil which your instructor will give you when you're ready"). Creating controls is perhaps the biggest challenge – it's impossible to control for EVERYthing, and students will have trouble finding the right balance. Only practice and feedback make this possible. In this case, only real-life experience will give students a chance to really consider the experiment from the perspective of how it works "in the real world."

How can you assess what they learn? In the PI lab, you'll be looking at very complex behaviours. Right now, I'll admit that the mechanism I've chosen for assessment is geared to the instructor's limitations. In a perfect world, the instructor would fully buy into the idea of giving the student everything they need to succeed in their original work, and simply acting as the "guide at the side" to give the student all they need to experience the project. In our labs, there are many groups of students who arrive with different motivations and a variety of levels of preparation. We *should* have a mechanism for the instructors to evaluate the "real science" that goes on during laboratory preparation. Instead, my compromise is to have the students write up the work in the same manner that a professional scientist would.

I chose Jan Pechenik's "A Short Guide to Writing About Biology" because it comes across as a "here's how it works in the real world" kind of guide. Tricks that are commonly related in conversation to graduate students but which are typically written down are given. "Write the Methods and Materials down first as you *know* how you did the work," "Write to illuminate, not to impress," and even tips about how to apply for a job are in the book. Checklists help students organize and prepare.

The book can help students initiate the tough job of communicating clearly what they've done. The problem is that students see that "Chapter 8: Writing a Laboratory Report" is o n e h u

n d r e d a n d e i g h t y pages long. The temptation is to breeze through without really trying to follow the advice. However, the laboratory is strongly integrated with Pechenik. If they're actively engaging the material, they'll have re-read relevant sections many times. Rather than query the instructor about formatting concerns, they'll be directed back to the book repeatedly. Instructors won't say *how* to fix something, but will rather help the students use the book's Table of Contents or Index.

I communicate to students that the lab follows the format that occurs with "real scientists." They write, revise, write, revise, and continue this an almost ridiculous number of times. The goal is always clear communication. Even the separation of the sections into "Introduction," "Methods and Materials," "Results," etc., are designed for easy illumination. The format has a purpose apart from "making things difficult for the student."

Okay, so what about assessment? We're asking students to do pretty sophisticated things in their first year. My philosophy is to clearly state expectations, give examples, and allow students to try to communicate their own way, provided they can give examples for how this is done in other professional laboratories. I set a high bar, as I believe this encourages high achievement. The target of the work the students will do is a "professional quality manuscript." Unrealistic as this is, I can attest that the first time I ran this, two groups came up with staggeringly good work!

The students are told in advance via a grading rubric (see following pages). The student can reflect on what a "better paper looks like" and consult with the rubric as they continue through their drafts. The power of the rubrics lie in their consistency with communicating to the students what the instructor expects, and it also provides graders with standards that promote consistency.

I change my rubrics from year-to-year to try to balance their ease of use to the instructors as well as identify clearly to students what we require of them. I've found that the rubrics have helped instructors to sort through the complex behaviours presented during the course of the laboratory. When students have appealed to other lab instructors about their grade, we find that by using the rubric, the marks are very consistent. This levels the playing field; instructors earn a reputation based on their classroom presence rather than their ease of marking.

To conclude, let me offer two early renditions of rubrics. The first is applied to the written work. The second evaluates the reviewer's contribution. I've modified the rubrics as an experiment; note that currently there are point values for the behaviours. We will move to a letter-grade only reporting mechanism. Students will see where they rank in each row by a checkmark where they stand in that department - the closer to the right, the higher they did in that according to the instructor. Of course, liberal comments on the report itself are required for specialized instruction. In the version displayed, the instructor sums up the marks after making these marks. The letter-only will minimize the instructor's accounting, and remove the strategy some students take to negotiate part marks.

To receive updated information about how this last effort worked out, drop me a line!

Regards, ...Todd

BIOL 2231 Lab Report Marking Rubric

Contributors: PI:_____

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Title					
Meaningful	Irrelevant, misleading, unclear, vague 0		Mostly appropriate 1	Clear & Complete 2	
On Topic	Unrelated to variables or outcome 0		Mostly appropriate	Targets experiment & deals only with organism, variables, & outcome 1	
Abstract					
Complete: All parts of the study are addressed	Absent 0	Mostly on target, describes study 0.5-2		Professional, clear, and comprehensive 3	
Brief: No excess information presented	Verbose 0	Generally conservative in words 0.5-2		Nothing could be cut to improve it 3	
Introduction					
Hypothesis is clearly articulated, is logical, and clearly identifies the variable being adjusted and the one being measured. The hypothesis makes a directional prediction; "If x is altered, then y will increase" – not "y will be affected"..	Absent 0	Unclear what is being studied. Experimental outcome not addressed 1	Variables merely listed / no prediction of outcome; illogical relationship of variables 2	Variables listed and prediction made. 3	Perfect; if/then statement with directional prediction 4
Background information - information to make the purpose and exploration of the phenomenon clear to the reader. The indep. and dep. variables are linked logically.	None 0	Sparse; sections of overall experiment are missing 1	Reasonable work, but could have more pertinent information, for example, the details of why the dependent and independent variables might be linked. 3	Mostly complete and covers major areas of the experiment. Link between independent and dependent variables is clear logically and with references.	Complete; this section describes in excellent detail all relevant parts. After reading the 5
Background points are **referenced**	Never or inadequate sources 0	Seldom or poor quality refs 0.5	Usually , with some to many good quality reference sources 1		Always referenced, sources excellent
All material is **relevant**	Content is mostly filler	Little content is relevant. 1	Somewhat appropriate.	Most material is essential.	All sentences are on target 4
Methods and Materials					
Comprehensible - text in M&M should read easily. Experiment should be clear based on how it was written. Awkward or convoluted descriptions are avoided. Point form / materials list is avoided.	Very unclear / absent / point form / materials list *is* included 0	Some steps described in vague or misleading ways - point form used 1	Most steps somewhat clear, though experiment would not be reproducible 2	Mostly described clearly with a few vague areas 3	Exceptionally clear throughout; good paragraph format 4
Completely described - experiment can be performed as described.	Many missing parts 0	Some steps described but with several gaps 1	Almost all aspects described in sufficient detail	Experiment is described clearly and completely	The design & steps are exceptionally clear
On topic - information provided represents the most brief, simplest way to carry out the experiment.	Full of extra, unrelated information 0	Many irrelevant portions; verbose 1	Most areas on topic and dealt with using an economy with words 2		Great writing - nothing off-topic or with excess detail 3
Steps explained & clear based on description & support in text - elegant experiment with careful control of all variables to ensure accuracy.	Many unstated assumptions, logic unclear 0	Several steps of the experiment left unsupported; logic unclear 1	The logic behind the experiment is fairly clear. 2	The protocol is logical and includes references to controls 3	All special or non-intuitive steps documented clearly and briefly 4

Results				
Graph / Table choice is appropriate for the data presented; trends clearly shown. Data are not given in raw form. Graph / Table has an appropriate, clear caption. Data are not presented twice unless new trends are indicated. The graph NEED NOT be computer-generated, but must be clean and clear.	Presentation not thought out properly. Another kind of graph or table would more effectively show the trends. 0-1	Reasonable presentation. The caption of figures and / or tables are appropriate. Graphs are of reasonable quality and are neatly rendered. 2-3		Trends clearly shown by graphing style selected. Data are presented clearly and the trends easily seen. Captions are excellent. Replicates are indicated and standard deviation or standard error is effectively communicated. Exceptional work overall. 4-5
Text in results section clearly supports data and explicitly references graphs or tables.	Minimal textual support, text passingly references data 0	A "shotgun" approach taken (everything given with the reader expected to pick out the trends and important points. Text is inappropriately brief. Clear trends are given, 1		Exceptional job with text; text clear, minimal, yet effective in guiding reader. Text resembles that of a professional manuscript. 2-3
Overall Data presentation - effective and clear; acts effectively for setting up the discussion section without itself interpreting the data.	Parts of results section are inappropriate 0	Judgment / discussion / interpretation mostly avoided, but does not necessarily set up the hypothesis for interpretation. 1		Exceptional presentation. Presented appropriately for maximum benefit for "discussion section". 2
Discussion				
Results are **related to the background** material and **applied to the stated hypothessis**	No link made and / or the introduction and conclusion don't complement each other	Background material mentioned. Intro and conclusion somewhat effective as a "single unit" – parts of the same paper. 2-3		Introduction and conclusion complement each other well. Hypothesis stated at the beginning is addressed and logic is again applied between independent and dependent variables. 4-5
Unexpected results addressed; future work explored	No analysis; cursory conclusion. 0-1	Hypothesis interpreted reasonably well, leading to suggestions for follow-up work, though these may be predictable. Logic for anomalies in data is not clear. 2-3		Brilliant interpretation; all data are logically explained. Clever extensions of the experimental system are put forward. 4-5
Conjecture clearly indicated - statements of personal interpretation are clearly distinguished from fact	Facts cannot be discerned from opinion; refs inadequate or ineffective.	Speculation is fairly clear, facts from literature are documented with reference citations. Reference quality is reasonable. 1		Good, logical conjecture distinguished from literature. References used to maximum benefit. 3
Literature Cited				
Proper Format (Pechenik, Ch 4)	Wrong format	Mostly consistent & correct 1		Consistently correct 2
Intro and Disc. referenced; **All refs appear in text**	Many errors 0	Only one has references and / or only some references are found. 1		Both sections contain references and all references are found. 2
Reference Quality	Poor, irrelevant	Moderate; textbooks or similar 1		Original journals or similar 2
Miscellaneous				
Clarity. Report is easy to read. Attention is paid to detail, grammar and spelling.	Not clear, details skipped 0	Many errors, details not addressed 1	Generally good clarity, report has good cadence & flow 2	Exceptional work. Very easy to read 3
Effectiveness. Work is extremely clean; extra effort to communicate points evident. The whole project is coherent, clever, and well designed.	Little extra effort is evident. 0	Some areas show effective presentation 1	Many areas show effective presentation 2	Most areas are effectively laid out and presented 3-4	Exceptional work. Logical points, insightful interpretation & layout 5-6
Professionalism. The experimental design is innovative, appears to be derived from thoughtful reflection, and demonstrates scientific effort.	Extremely "amateurish", lacks polish 0	"High school" level. Much improvement needed 1	Reasonable "freshman level" manuscript. 2	Final work resembles actual manuscript 3

BIOL 2231 Report Review Marking Rubric

Contributors: PI:_____

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Title			
Participation - All members are expected to contribute to the experiment. The PI is only the facilitator and it is up to the assistants to ensure that the work is performed quickly, thoroughly and competently.	Minimal participation -or- member not present / late / otherwise not a productive member. The student needed prodding to participate or excessive direction to complete his or her tasks. 0-1	The student is involved as a useful contributor to the project. There was little standing around or irrelevant discussion (unless tasks were completed and no other useful activity was possible). 2	The student was a very effective team member. The student offered good suggestions to the PI and/or helped rectify unexpected difficulties in completing the experiment as originally planned. Tasks were accepted, and suggestions for improving the procedure were offered. 3
Knowledge - The participants must understand the goal of PI labs in general and the experiment in particular. He or she must engage with the material clearly, confidently and correctly.	The student does not demonstrate a good understanding of the material either by not participating, asking irrelevant or uninformed questions, or through behaviour that in general indicates a lack of awareness of the project. 0-1	The student behaves as if informed of the intent of the experiment and goals required by the team. Insightful suggestions are given and the student gives useful comments and direction to other team members. 2	The student engages the instructor in the project by asking questions or making comments that indicate confidence with the material. The material may be related to other observations, readings, or world experiences in a logical way. 3
Literature - Useful, well-thought out references must be provided. To further help the PI, a clearly-written synopsis of the literature should be provided, highlighting relevance to the manuscript as well as indications of how they might be useful for the finished paper.	No literature or only marginal effort in selection was evident. 0-1	A print reference was provided that was adequate. The print source was of a fairly recent source (e.g. a textbook). The supporting text (synopsis) was easy to read and reflected a logical way to allow the PI to incorporate the information into the manuscript. 2-3	A very relevant primary literature reference was offered. The supporting synopsis clearly demonstrated to the PI how the work could be incorporated into the manuscript. 4
Timeliness - All deadlines must be met and colleagues must try to accommodate suggestions. Extra points can be allotted for creative use of resources to meet in the face of adversity (for example, meeting at the "virtual classroom" at http://courseinfo.mtroyal.ca).	PI was hindered by lack of timely feedback. 0-1	Schedule was adhered to. Some indications of extra effort to meet with PI and other group members is documented. 2-4	PI makes note that feedback was returned within a particularly acceptable window or that exceptional effort was made to help with revision 5
Clarity - The marked-up manuscripts show need to give clear direction to the PI about what needs to be changed to improve the paper. Feedback need not be through multiple revisions and reviews; the most effective revisions should be done as a single, comprehensive evaluation of the PI's best work. Comments must be clear and, where possible, reference sections of review articles, the lab manual, and / or Pechenik.	Incorrect, irrelevant or misleading comments are provided. The reviewer comments appear to be mostly "filler" that does not improve the quality of the manuscript substantially. 0-2	In general, the comments improved the manuscript. Most major formatting errors were caught, and proper correction was indicated either by re-wording areas or referencing writing resources. The PI would have little difficulty in improving the manuscript based on the direction indicated by the reviewer comments.3-4	Without exception, the comments provided by the reviewer were insightful and appropriate. The instructions were clear and easily incorporated into the final product. 5