Responding to student writing in the life sciences

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Teaching scientific writing is inherent to life science education. But although we may be skilled at writing scientifically ourselves, it is often difficult for us to provide students with the kind of feedback that helps them to progress as scientific writers. One of the reasons is that, although scientific writing is a continuously developing skill, we often judge student texts in isolation, not taking into account often enough what a student knows and should know. In this article, I argue that for any writing task our feedback should primarily focus on the skills we aim to teach with a writing task, not on the errors the students make. By treating writing tasks like we would laboratory exercises – with specific learning goals in mind – we can avoid many of the pitfalls that make learning scientific writing difficult for students.

Keywords: scientific writing; feedback; assessment; writing across the curriculum; lab report; undergraduate studies

Introduction

Teaching writing in the life sciences often takes a backseat to teaching science. This probably comes from the false dichotomy of thinking that teaching writing is somehow separate from teaching science (Gottschalk and Hjortshoj 2004). In reality, writing is being used in university science courses to get students to think about science, learn science and provide us with valuable feedback on whether students understood science (Ebel et al. 2004; Quitadamo and Kurtz 2007; Libarkin and Ording 2012; Reynolds et al. 2012; Anderson et al. 2015). And every time we provide feedback on written texts, our roles switch from science educators to writing teachers (Hattie and Timperley 2007).

Although there are several writing tasks used to teach scientific writing (e.g., essays, literature reviews, grant proposals), the most ubiquitous one in biology is the *laboratory report* or derivatives of it (Lerner 2007; Cordes 2016; Pechenik 2016), a format also used in physics (Thompson 1970; Etkina et al. 2006) and chemistry (Rosenthal 1987; Cacciatore and Sevian 2006). Lab reports typically mimic the structure of scientific peer-reviewed articles (IMRaD: Introduction, Methods, Results and Discussion) and not only summarize experiments and their results but provide context by illustrating how the experiment fits into the associated scientific literature (Cargill and O'Connor 2013).

These similarities create a problem for academic science teachers when providing feedback to student texts: We are prone to treat lab reports of students just like we would the manuscripts of colleagues. But while students (early BSc students in particular) generally want to know what they need to improve to receive a passing grade – a perfectly valid viewpoint –, teachers often highlight all deficiencies and suggest all improvements needed to create an acceptable report (Gottschalk

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and Hjortshoj 2004; Glover and Brown 2006). Such mismatched expectations, I argue, can be avoided by clearly communicating the learning goals for the writing task (see Box 1) and by focusing for the feedback on where students failed to reach them (Gibbs and Simpson 2004; Nicol and Macfarlane-Dick 2006) Instead of spending a lot of time on corrections, suggestions and in-text discussions, we can limit our responses to the two or three most relevant problems and assist students in revising their texts (Straub 2002).

The following suggestions for providing feedback to students in the life sciences are synthesized from the large body of empirical literature predominantly from the humanities. The natural sciences have so far provided little input into the discussion on what qualifies as effective written feedback (e.g., Glover and Brown 2006), but many aspects of responding to student writing and the arguments used in other disciplines should apply even to such rigid formats as the lab report or grant proposal.

What to give feedback on

Focus on the two or three most important aspects

Many teachers tend to follow the perception that they must help students write a perfect text, or correct every single problem (Brannon and Knoblauch 1982; Gottschalk and Hjortshoj 2004). This expectation is completely unrealistic, especially for first-year students. For no other scientific skill do we set such high standards so early in academic careers. The goal for students' lab reports should be that students learn – through their writing – how scientific questions are answered and what role specific scientific concepts (like those practiced in laboratory sessions) play in this process. They should acquire skills like structuring scientific experiments or understanding the role of the scientific literature in identifying gaps in our knowledge. The end product should therefore not be a perfect text but merely evidence that the main learning goals – irrespective of whether those are scientific or writing skills – have been achieved through the writing task.

Often, the type of feedback we give is more important than the amount of feedback (Zamel 1985; Grant-Davie and Shapiro 1987). If we respond to too many aspects, students will find it very difficult (if not impossible) to identify the most relevant problems we have with their writing (Gottschalk and Hjortshoj 2004). As a consequence, they will correct *everything* that we marked and effectively become correction machines for the instructor instead of revisers of their own texts (Brannon and Knoblauch 1982; Sommers 1982; Willingham 1990). For students to learn from our comments, they must understand what we want them to learn. If we give them the opportunity to rethink and revise their texts based on a few points of criticism, students will avoid making those particular mistakes in the future (Willingham 1990). They learn from our feedback.

From an instructor's point of view, feedback on a student's text should only serve one purpose: to guide students on how to do the revision (Mallonee and Breihan 1985; Moxley 1992; Hodges 1997; Hattie and Timperley 2007; Bean 2011). This usually applies to the revision of the manuscript that we are giving feedback on, but it is also guidance for writing another text in the future (Gibbs and Simpson 2004; Nicol 2010). In both cases, the instructor's comments serve the purpose to help students write better texts than they did before. So irrespective of whether we give feedback on text structure or some scientific background, when we decide *what* to comment on, we should consider two questions:

- *What can you expect your student to know at this point in his or her education?*
- *What do you expect your student should know after performing this writing task?*

When giving feedback, our job is to focus on the latter (after all, this was most likely the learning goal for the task) and to heed the former (there is no point in criticizing what a student cannot yet know). This is why learning goals are so important – if we did not define something as a goal for the task, we should not make it a goal for the revision.

Differentiate between higher-order and lower-order concerns.

As scientists, we receive major and minor comments as feedback on our own submitted manuscripts. The same concept should apply to feedback on student writing (Glover and Brown

Box 1

The difference between learning goals and scientific questions in writing lab reports

A common problem for students is that they do not understand the difference between a learning goal and the goal of the experiment (i.e., the scientific question that they should try to answer with an experiment). This often leads to reports that start with "The goal of this experiment was to understand how a gel electrophoresis works." For students to learn the nature of scientific writing, it is essential to take that first step in doing science: understanding the question behind their research.

If coming up with a good **scientific question** is not the deliberate learning goal set by the instructor, it should be the instructor's task to communicate the question in advance. Without it, students will neither be able to understand the point of the experiment, nor write about it. They will remain on the level of the student who just performs a task as well as possible, without understanding that they are contributing to the scientific knowledge on a particular topic.

On the other hand, instructors should keep in mind the **learning goal** they have set for a task. If they don't have one, how can they judge whether students learned what they should? If they have not set writing goals for a writing task, how can they criticize what the students wrote? Students' primary interest in receiving feedback on any task they perform is to know whether they did well. This can only be decided if we know what we want students to achieve.

2006). *Higher-order concerns* can include text structure, question and argument; *lower-order concerns* may deal with paragraph structure, style and grammar (Reigstad and McAndrew 1984). Students often think they struggle with lower-order concerns (*I don't know how to say this scientifically.*), whereas the problem usually lies with higher-order concerns (*I really don't understand why we did this experiment.*). By shifting the focus to the bigger picture of common problems with student texts, we put the emphasis on what we think is important for a revision (Willingham 1990; Straub 2002). Does it, for example, really matter to us whether students write in active or passive voice if they still don't understand the purpose of an Introduction? When we read a lab report, we should remember that we are teachers and readers, not copy-editors. After students have addressed the higher-order concerns, many lower-order concerns may disappear in the process of rewriting, saving us and the students both time and effort (Bean 2011).

By distinguishing between higher- and lower-order concerns, we decide what we think students should address first in their revision. If we respond to higher- and lower-order concerns equally, we communicate to students that we think they are equally important to us (Willingham 1990). It is a lot easier for students to just rewrite a sentence than to think about why the paragraphs leading up to their hypothesis don't explain the reasoning behind it. Lower-order concerns are often the easy way out, that's why it's so tempting for both instructors and students to jump at them first.

Mention good aspects of the text as well as bad aspects.

There are two good reasons for praise: First, good comments mitigate the criticism and tell the students that what they did was not all bad; this motivates them to revise their texts at all (Bean 2011). Second, students want to *know* what they did well as much as what they need to improve. A compliment is positive reinforcement that elicits learning (Elbow 1997; Hattie and Timperley 2007); criticism only makes them aware of what they already know – that they are still *pretty bad* at scientific writing. To many undergraduate students, these are the first times they write scientific texts. As important as it is to show students where they struggle most, it helps them to learn what

they are doing right. Only because students have done something right the first time does not necessarily mean that they understood that they did it right the first time.

How to give feedback

First and foremost, tell students what is expected of them for the writing task before they submit their texts.

Students can only achieve the goals we set for them if they know what they are (Nicol and Macfarlane-Dick 2006). If a student writes a lab report on an experiment, they must know that the aim is to answer a scientific question (see Box 1) in a scientific format. This could mean that they need to document the experiment, give sufficient context to the relevance of the question, perhaps formulate a hypothesis and test it – it is the instructor's job to define what this task involves. Sometimes students are asked to write a literature review or an essay for a student textbook; in such cases, we should outline to the students what we understand each of these to be. For first-year students, a literature review is a brand-new format. An essay, on the other hand, can mean different things to different instructors, so it's impossible to expect students to know what we understand an essay to be. We need to *know* what we expect our students to do and *communicate* these expectations clearly (Hattie and Timperley 2007). A useful way to achieve this is to hand out a checklist of criteria by which students will be judged (Mallonee and Breihan 1985; Anson and Dannels 2002).

Read the whole text first.

When it comes to responding to student writing, there's no advice better than this: Read the whole text without making any comments (except for the occasional note or question mark if we notice a major problem while reading). The reason behind this strategy is that the most important task for us as teachers is to decide which problems we should focus on in our feedback (i.e., our higher-order concerns). And that is a decision we can only make once we read the whole thing (Elbow 1997, 1999). If we start writing comments straight away, we make the same mistakes our students make if they hand in unrevised first drafts. Our feedback should be the revised version of our thoughts, not our first draft.

Try to write as little as possible in the margins.

When communicating the main problems we have with a student text, we should try to strike a good balance between margin comments and end comments to make clear what it is we really want students to take with them from our response (Hodges 1997). Some specific comments are helpful, but the more we add, the more they distract from our main message (Mallonee and Breihan 1985). On digital drafts, many comment bubbles next to their text can convey to students the first impression that we thought little of the quality of their texts, even if the comments themselves are mainly favourable.

Write comments in full sentences that are clear and precise.

Students should be able to immediately understand what our problem is (Gibbs and Simpson 2004). Ambiguous comments only create misunderstandings. If we simply cross out whole passages or put question marks in the margins, students are left with question marks regarding our comments. There is no way this can be a productive and effective learning environment. Similarly, when writing on printed copies, we should write legibly. What students cannot read, they cannot learn. Sometimes it helps more and saves more time to actually sit down and discuss a text with the student than to respond with written comments. (For some good advice on how to efficiently structure one-on-one discussions with students and other time-saving strategies, see Bean 2011, Chapter 15.)

We should leave the responsibility for the revision to the student.

It is the student's job to rewrite their text, not ours (Brannon and Knoblauch 1982; Gottschalk and Hjortshoj 2004). This is why focusing on main problems is so important. By asking a question about the experiment, we leave it to the student to think of an answer that could be incorporated into a revised text. By suggesting changes instead of dictating them, we leave it to the student to decide

whether these are valid. Instead of correcting every spelling mistake, we can count the errors in the first passage and inform the student about the poor orthographic quality of the text. If they care, they will find mistakes throughout their text and correct them; if they don't care, correcting them for them does not help either.

Be aware of your subjectivity when responding to students' texts.

What one considers to be right or wrong in a student text may differ even between closely related disciplines (Haar 2006). We only need to look at the slightly different sets of author guidelines of life science journals to find that the details are often open for debate. When responding to student writing, our comments may therefore differ from, or even contradict, those of other teachers – something of which the student is probably more aware than we are. By phrasing our comments as verdicts (e.g., *Never write in the active voice.*), we provoke students to disagree with them (Elbow 1997, 1999). While such disagreement is something we should generally encourage in students as they begin to think scientifically, it makes it more difficult for us to reach students with what we think is good advice. We should therefore at least acknowledge our subjectivity. By seeing ourselves as readers and addressing the students as authors, we can create a dialogue with our comments – and dialogues encourage students to respond (e.g., in the form of a revision) (Willingham 1990; Straub 2002; Nicol 2010).

Keep in mind that students may not yet know how revision works

First-year students often do not yet know how a revision works (Sommers 1980), and rewriting paragraphs on a new and complex subject can introduce new grammatical and syntactical mistakes (Schwalm 1985; Bean 2011). To have students rewrite a text until they get it right may therefore be an exercise in futility. If we communicate clearly which aspects we think are of higher-order concern and why, it can be sufficient to ask students to only revise certain aspects and just keep others in mind for the future (Moneyhun 2002). Revising scientific texts should be a learning goal for the Bachelor's program just like any other scientific learning goal. Students should understand that revisions are an essential part of the scientific writing process (and not punishment for not getting it right). Feedback and revision must therefore be linked to the original assignment and not be spread over the course of a semester (Gibbs and Simpson 2004).

Conclusion

As most of us can attest, scientific writing is a skill that is never fully acquired. It becomes easier to start a new manuscript; we become faster at finding relevant literature; we publish articles that are somehow more readable than our dissertations were. But writing remains a struggle. Continuously developing skills like scientific writing require different teaching methods than does scientific knowledge. A thing that a student needs to memorize for an exam can probably be taught in a single lecture by a single teacher, but a skill requires consistent reapplication over years, a time during which many teachers pass through a student's life. For us this means that teaching writing is never a task performed in the vacuum of a student-teacher relationship. What one person teaches has repercussions on how effective the teaching of another will be.

Differences in our writing standards are something we need to address and communicate. Naturally, expectations change over the course of the curriculum, but the standards by which we judge students at different levels may not match up between instructors. To address these different expectations, it helps if a faculty discusses and agrees on overall writing goals and incorporates those as learning goals into the curriculum (Anson et al. 2012). Having transparent learning goals not only for the scientific content that is relevant for exams but also for continuously developing skills like writing, can serve as a guide to instructors when responding to student writing. More importantly, however, it gives students a clear understanding of what we expect them to learn at what point over their academic career. This way we can move responsibilities to students as they progress through their studies and focus instead on the learning goals we set at a given stage. Clear writing goals can therefore improve the communication between student and teacher, which is an

essential requirement for effectively responding to student writing.

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