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Investigating the level of support for student learning in scientific writing

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Background

The course “Plant Genomics” is aimed at second year undergraduate students from Biology-Biotechnolgy, Agriculture and similar study programs. The course consists of different modules covering different aspects of plant genomics. I was involved in teaching one such model on tracking gene expression over the course of 1.5 weeks in the spring of 2014. The module consisted of lectures, laboratory exercises and a report written by the students. While we had provided the students with some questions to be answered in the report, we had not given written, detailed instructions on the form and the content of the report. We had expected that the students knew how a scientific report should be written at this point of their studies. However, from the reports handed in, it was clear that this was not the case; the quality of the reports was poor, they lacked content and depth. Talking to the other teachers in this and similar courses, I found out that they had experienced similar things. To understand the reason for this, I decided to assess the students’ view on report writing and if they possess the expected prerequisites to write a report as we expected them by conducting student interviews. The outcome of the questionnaire pointed towards that we had overestimated students’ abilities in scientific writing at this stage, something that was already clear from the reports we received. Therefore, I revised the questions to be answered in the report and wrote additional guidelines for the students to follow in order to be able to write a report at the scientific level we expect of them.

Introduction

Science education often involves practical laboratory exercises, where students conduct experiments following given instructions, and afterwards write about the experiments and their outcomes in a report. One idea behind having students write is to facilitate the construction of scientific knowledge and the development of students' scientific literacy (Keys et al. 1999). Having to find the right language for what they want to communicate will make students reflect on the meaning, at the same time as the meaning becomes clarified through the language (Keys 1999). As scientists they will have to communicate their research via writing, following the conventions of their field, and it is as students they learn how to do this.

Applebee & Langer (1983) liken the learning of scientific writing to a child learning to speak. In order to develop language, it requires scaffolding provided by the parent (teacher) which helps the child (student) to complete tasks which it could not complete successfully on its own. In school learning this scaffolding comes in the form of lesson structures, framing of exercises and textbook materials, and the teacher's comments and discussions. The scaffold gives a secure environment for the student to learn the new strategies and patterns, so that he will not need the scaffold for similar future tasks. When using this approach, Applebee and Langer give three steps the teacher must follow:

a) Determine the difficulties that a new task is likely to pose for particular students.
b) Select strategies that can be used to overcome the specific difficulties anticipated.
c) Structure the activity as a whole to make those strategies explicit (through questioning and modelling) at appropriate places in the task sequence.

In laboratory courses, students meet several kinds of report writing. Often the early laboratory reports are tightly structured, the kind of "fill in the blanks" or with many closed questions looking for specific answers. While this form of report provides scaffold for students to deal with new content, it focuses the students' attention on isolated aspects of knowledge and does not help students to reflect on new ideas, or to integrate and apply them in new ways and make them their own (Applebee & Langer 1983). On the other end of the scale, we have the open format, where no scaffold is provided and the students are expected to deliver both form and content. According to Applebee and Langer this form of writing is good for assessment but not for instruction, as the students' task is to recite material which they have already mastered and not to explore new and more difficult forms. In between the "fill in the blanks" and the completely open format there is a gradient of closed to open report forms.

In order to determine the level appropriate for the students of Plant Genomics, I investigated how students perceive report writing at different levels. Finally, I made some changes to the instructions for the report writing, taking the level of support the students require at this stage into consideration.

Methodology

A questionnaire about lab report writing was designed and distributed to volunteering students. The questionnaire asked about the study program and start year as well what experimental courses the students had and questions to the form of reports they had had to write in those classes. Furthermore, if students thought the report form supported their learning and what was their preferred report form and why. Seven students in total participated: five of the students are third year biology-biotechnology students (students A-E), one student is a fifth year biology-biotechnology student (student F), and one student is a fifth year agriculture student (student G).

Results and discussion

The students that answered the questionnaire fall into two categories. Five of them are bachelor students, all in their final year and all studying biology-biotechnology (students A-E). Two are master students, one studying biology-biotechnology (student F) and one agriculture, although this student has a bachelor in biology-biotechnology (G). Table 26.1 gives an overview of the answers from the questionnaire. Many of the students have had the same courses (several of the courses are mandatory courses for the biology-biotechnology program). From the answers it appears that the laboratory reports in the early courses are of a more closed format (type 1 and 2) but some slightly more open formats are also found (type 3), namely in molecular genetics and chemistry, although answers for the latter vary considerably. Laboratory reports in courses for master students appear to all be of a more open format (type 3 and 4), which fits well with the advanced level scientific writing we expect from students at this stage in their education.

From the answers to the question if the report form supported student learning, it appears that there is an overall agreement between report form and students' learning. The only disagreement is mentioned by students C, D and E in courses chemistry and biochemistry. The comment made by E for biochemistry is in agreement with what Applebee and Langer say about "fill in the blank" type of reports, which they say are not helping students to complete tasks more complex than they would otherwise be able to carry out but on the contrary are simpler than what students would normally do on their own. However, the majority of students answered that they thought this report form was appropriate and supported their learning. From their comments it is clear that they see this form as supportive because it asks direct questions of them. It is solid scaffolding, and they feel very safe within it. At the same time A also comments that this type of report does not stimulate reflections, in other words it might encourage a surface learning approach (Biggs & Tang 2011*a*). As teachers we want students to engage in deep learning, and therefore we should take care in formulating questions that include aspects such as describing, explaining, relating, applying and theorizing to allow for such an approach.

Students also answered a general question about their preferred report form. The answers fall into two overall categories, some prefer the more closed and some the more open format. B, C and D prefer closed formats, while A, E and G prefer the more open formats. F comments "*I think it depends on wich [sic] level you are on. In the beginning it is good it is fixed and with questions. The higher level des [sic] more open format. In this way I think you learn the best.*", which is in beautiful agreement with Applebee and Langer's scaffolding theory, and reflects the answers from the other students. B, C and D express that the closed format gives them security. They may not yet have reached a level where they have mastered the scientific writing, and thus they need more support to have room for practice.

B: "*Either to fill in or with lots of questions, so you have the opportunity to consolidate the right things. Good way to give the right problem formulations and methods the right attention.*"

C: "*Fill in the blanks/answers in form of paragraphs in a fixed structure with given questions. I think the important thing is to clarify the pur-*

class	student	type of report	did the form support your learning	comment
Chemistry	A	2+3	yes	Made me understand the chemical reactions and the theory behind
	B	3	yes	I understood the experiments after having written the report
	C	3	no	There was not enough focus on explaining the parts that had been misunderstood. It is more difficult to remember the things you learn from this type of writing.
	D	1	no	
	E	2	yes	It was good, because we learned the things we needed, but not how to write scientific.
molecular genetics	A	2	yes	Lot of questions to help us understand the methods we used in the lab and why we used them. Some of the reports had some quite open questions which made the report more essay like. That was also learningfull.
	D	3	yes	
	E	3	yes	I think it was a good way to learn the supported things, and how to write a report
	G	3	yes	Yes, you allways learn at lot from having to write down your knowledge.
biochemistry 1	A	1	yes	It helped us to understand the most basic parts but it did not make me reflect about the results or methods we used.
	B	1	yes	Good way to learn, in that you are forced to answer relevant/difficult questions
	C	1	yes	It focused only on the most important things, which is nice in a basic course like biochemistry - it makes it easier to remember
	D	1	no	
	E	1	no	I don't like this kind, because i don't think I learn so much as I can.
plant genomics	A	3	yes	Yes, i learned a lot but mainly because i spend a lor of time on the reports
	E	2	yes	It is good to learn all the theoretical because the right questions are given before hand. But I don't learn how to think critical, because we don't at this type.
Experimental molecular biology	A	2	yes	Yes, there was a lot of questions to help us undersstand all the methods and background and some questions asked to make us reflect . Sum up: really learningfull
	B	2	yes	Good with questions so you are sure to have understood the experiments
	C	1+2	yes	There were different kinds of report forms, but they all focused on the important things we needed to learn from the experimental part of the course. Explanations but not necessarily answers were fiven -> you had to thinkg for yourself -> you learn.
	D	2	yes	
	E	2	yes	Here, the questios are more guiding so we learned how to think critical and how to write a scientific report.
Advanced plant biology	B	2	yes	Good way to learn, in that you are forced to answer relevant/difficult questions
experimental plant science	G	3	yes	
Quality and postharvest biology of plant products	G	3	yes	We wrote an article
thematic course	F	3	yes	Writing the report was a way of putting our learning into context.
Bachelor project	F	3	yes	"Result was" very good, we had also planned the format together
research placement on transposon activation by pathogenic yeast	F	4	yes	Yes for the same reasons as third year comment (thematic course)
special topics on plant transosable elements, biology and epigenetics	F	4	yes	Yes, this was my first comletely letterature based report and making the transition from an introduction to a full report was good to learn.

Table 26.1. Students answers to the questionnaire. Students A-E are third year biology-biotechnology students and student F is a fifth year biology-biotechnology student. Categories for type of report are 1: fill in the blanks (short answers and calculations), 2: write answers in form of paragraphs in a fixed structure with given questions, 3: write report as continuous text after a fixed structure and 4: completely open format.

pose of what you are doing and the rest should be in relevant questions, that make you understand the theory behind. I don't think you learn from writing a continuous text after a fixed structure; it makes you loose [sic] focus on what is actually relevant."

D: "*Not report scheme, but a lot of questions to answer in form of paragraphs in a fixed structure. I think that I learn the best by this.*"

The other two third year students prefer a more open format, but still with some support:

A: "*I like the more open reports (aim, theory, methods, discussion) where you write a continuous text but the report form where you answer questions in form of paragraphs is also good because it can help you to understand details that you haven't thought about yourself. My preferred form is where you have to answer certain questions in the report but the format is open. I think that works really well.*"

E: "I think I would prefer a report as a continuous text with a fixed structure, because I learn most from the feedback, and not so much from the report itself. It's the feedback that shows me how to write and how the structure should be, because I don't notice how the structure is when it only is questions."

Both students appear to be at a more advanced level, they can see that the open format is relevant for them, but they are aware that they have not yet mastered it. For them, guiding questions and feedback from the teacher would probably be good support (Applebee & Langer 1983).

From the students' answers it appears that our original assumptions, that students are able to independently write a report, were wrong. Students at that level need a more supportive structure in which they can practice. Therefore, I decided to revise the instructions for the "tracking gene expression" module of the "Plant Genomics" course to be more supportive.

Revision of instructions for report writing

The teaching material for the laboratory exercise in "Tracking gene expression" contains an introduction to the discipline with explanations of the methods being used. It furthermore introduces a biological case that is used as the basis for the experiment and states the aim of the investigations. Students conducted the experiments and wrote the report in teams consisting of of three to four students. The exercise consists of a wet lab part and a computer exercise. For the wet lab part, some specific questions about the lab work and the results are given that should be answered in the report. The guide for the computer exercise contains stepwise instructions for the data analysis and throughout the instructions, there are questions marked in bold which students should try to answer in the report. We had orally informed the students that the report should contain an introduction, materials and methods, results and discussion. However, most reports we received were poorer quality than we had expected. To improve the learning for the coming students in the course, we will add a description of what we expect of the report in the guidelines, in addition to the inquiring questions that help students to think about what they did in the lab and why and to reflect upon their results. Because the inquiring questions are specific to the laboratory exercise and would make little sense to the reader, I have omitted them here. The section below will be included in the guidelines for the future:

The report should be in the form of a research report and consist of the following sections:

- Introduction
  - Gives background information and ends with the aim of the present study
- Materials and methods
  - Should contain enough information so that other people can repeat what you did
- Results
  - Including figures and tables. Legends have to be sufficiently detailed so that the figure can be understood on its own.
- Discussion
  - Discuss your results. Where your findings as expected? What can you conclude from the results? What went wrong and possible reasons why?
- Conclusions
  * As this report comprises several experiments, it is a good idea to use sub-headings to help the reader follow what you write about.

From answers in the questionnaire it is clear that the students have some ideas about report writing, some a clearer picture than others. Since future students in the course might have different standpoints, we should try to meet them where they are. For this, a teaching session could be dedicated to how to write a report. This session will be dialogue based, requiring the students active participation. Together with the teacher, students should formulate how a lab report should look. This session will hopefully inform about where the students stand and then build up the structure in plenum from there. My idea with this session is also that during the process of describing what a report should contain, students realize that most of them actually know what is required. By formulating the above given guidelines themselves they will also have internalized them more than by just reading them in the instructions for the exercise.

Concluding remarks

Asking the students about their experiences with writing reports in laboratory courses showed that our assumptions about their level were wrong. This also showed that it is important as course teacher to know the levels of ones students to support their learning. Although several groups in "Plant Genomics" handed in reasonable reports and one group even handed in an outstanding report, I believe that by adding a little more structure, more students can reach a higher level of understanding and that the general quality of the reports will be improved. Allowing students to formulate writing in a structured way will hopefully deepen their understanding of both the practical experimental part as well as their scientific writing skills.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2015-8/

The bibliography can be found at:

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