Structured preparation prior to laboratory teaching activities

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Background

The activities described in this paper are aimed at undergraduate science education, more specifically at practical exercises within the biomolecular sciences. As an experimentally grounded discipline, the educational program encompasses learning activities focused on conceptual understanding as well as analytical and practical competences.

One type of learning activities molecular biology students often encounter are practical exercises in the molecular biology laboratory aimed for development of practical and/or analytical competences. For large student-number courses, these exercises are often highly structured with limited degrees of freedom with respect to activity design, leading to a consequent lack of demands for student participation prior to the practical exercise in contrast to exercises where students need to design the experiments to be performed themselves before going to the laboratory.

In the bachelor program of Molecular Biology at Aarhus University, we have several mandatory courses with practical exercises for large student numbers with the largest course having around 220 students enrolled. The practical exercises on these courses are fully designed by teachers, and the student preparation for these modules involves the reading of practical instructions and theoretical considerations in a laboratory manual accompanied by what activity the students might find necessary to “feel prepared”. However, as teachers we experienced many situations in the laboratories where the student preparation at best was insufficient. We therefore decided to aid the students in the selection of appropriate preparative activities prior to laboratory exercises.

Students’ learning outcome

The primary learning outcome of these supportive activities is that students are better prepared for the practical tasks as well as being more familiar with the topic under investigation when performing experiments in the molecular biological laboratory during their bachelor program. We believe this supports the development of analytical skills in relation to laboratory exercises by enabling communication at higher abstraction levels while performing experiments. In other words, we wished to set the ground for learning activities described by higher-order SOLO verbs in the SOLO-taxonomy (Biggs and Tang 2007) .

Description of activities

In our perspective, the precondition for successful support of competence development from laboratory exercises is that the students have an overview of what they need to do in practice and why, and furthermore that they can relate the activities to the theoretical field of analysis with its

variables and internal correlations. We therefore designed two mandatory online assignments to be completed before the scheduled laboratory activities; one activity intended to prepare the students for what was planned to take place in practice while the other activity was designed to help students gain an overview of the analysis field in question.

To support student preparation for practical aspects of the laboratory exercises, we have designed Multiple Choice Tests (MCT) – one for each laboratory course – only addressing practical aspects of the exercises. In order to be able to answer these questions, the students need to read the manual carefully and since protocol steps are addressed throughout the entire manual, students are encouraged to read it all. An additional benefit of this activity is that we can direct student attention to particularly essential protocol steps, the importance of which might fade in the context of the entire exercise. Immediately before going into the laboratory, students and laboratory teachers meet for an introduction to the practical exercise and all MCT questions are discussed in this setting. This helps students to address any remaining misunderstandings of what to do and why, and helps teachers to identify protocol steps needing special attention when "in action".

To support student preparation for understanding the analytical variables and their interrelationship, we ask the students to make a small half-page written assignment focusing on the conceptual understanding of the biological system/mechanism investigated. The assignment guidelines describe which variables should be addressed and on which taxonomical level (e.g. list/describe/compare), and the students are welcome to include figures/models in their assignments if they find it appropriate or helpful. The assignment is evaluated by anonymous peer-feedback, with each student giving feedback on two assignments, based on correction guidelines focusing on constructive feedback. Finally, the assignment - which is often adjusted according to the feedback - is handed in as part of the final report for the overall summative assessment.

These activities have been implemented in three bachelor courses in molecular biology with app. 120, 160 and 200 students, respectively. The assignments are set-up in the learning management system known by students and teachers, and easy data handling with respect to MCT results as well as automated assignment distribution for peer feedback make it a technically rather manageable task.

Evaluation of activities

As teachers, we experience that the laboratory activities are conducted more fluently with less mistakes and a consequent quicker progression through the manual. The reduced time is not a criteria for success, but we interpret it to be the consequence of better-prepared students who, to a very little extent, need to repeat protocol steps. We also experience students asking questions reflecting more complex considerations and discussing protocol steps at higher taxonomical levels than before, with a concomitant reduction in need for basic descriptive information related to the practical aspects. In order to evaluate the MCT from the student perspective, we made a five level Likert-type scale survey with items addressing different aspects of the initiative. When asking students whether they prepared more thoroughly for the practical aspects of the exercise 20% (of

150 respondents) responded that they would have prepared equally well if the MCT had not been there, as represented by the dark blue and yellow fractions in Figure 1. However, 60% felt better prepared due to the presence of the MCT as represented by the orange and light blue fractions in Figure 1. From our perspective, this is a very satisfying outcome.

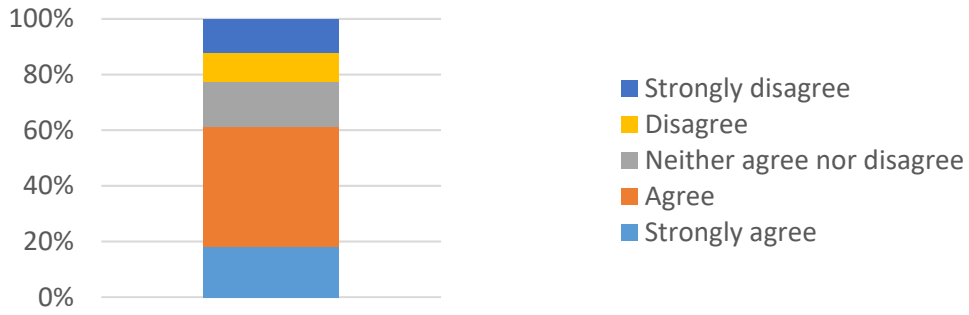

Figure 1. Evaluation of student responses to the statement; "I have read the laboratory manual more carefully because I had to do the multiple choice test". The data is based on 150 respondents.

In a qualitative survey, students responded that the MCT was important as motivation for reading the manual, but the test was also appreciated for its ability to help students judge whether they had understood the essential parts. The latter point is also illustrated by the fact that some students try to identify the correct answer on wrongly answered questions prior to in-class activities, although not being allowed to re-submit the MCT, merely for the sake of "getting it right".

With respect to student preparation for understanding the analytical variables and their interrelationship, we experience a significantly reduced need for clarification of concepts during the practical exercises allowing a more qualified discussion to take place while performing the experiments. In order to evaluate the written assignment from the student perspective, we made a questionnaire with closed questions. When asking students whether they felt better prepared due to the presence of the written assignment only 10% of 116 respondents reported to consider themselves as prepared as they would have been without doing the assignment (depicted in orange in Figure 2) .

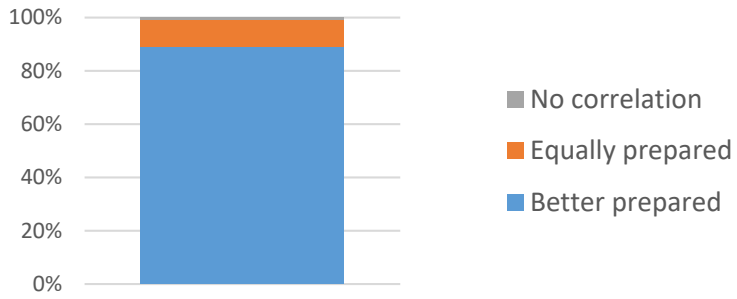

Figure 2. Self-reported student distribution on agreement with the following statements: A: "I would have prepared equally well on the theoretical concepts without the written assignment" (fraction depicted in orange), B: "I am better prepared on the theoretical concepts because I had to do the written assignment" (fraction depicted in blue) and C: " I do not see any correlation between the written assignment and the laboratory exercise (fraction depicted in grey). The data is based on 116 respondents.

In a qualitative survey, the students underlined the motivating aspect of the assignment in relation to preparation for in-class activities. Interestingly, the students stressed the benefit of having to give feedback on two assignments as they contrasted them against each other as well as against their own assignment.

In conclusion, we experience a clear improvement in student preparation for practical exercises after including two mandatory online activities structuring the preparation prior to in-class activities, and although students find these activities time-consuming, they acknowledge the supportive potential of the MCT and assignment and evaluate them very positively.

Generalisability

On a general level, this is an example of structured mandatory preparation prior to in-class activities. Although we have always stressed the importance of preparation prior to practical exercises, it was not until we nourished the motivation by including mandatory preparative activities that we gained the desired outcome.

More specifically of relevance for subjects with experimental laboratory classes, this set-up can be directly transferred to other subjects to increase student preparation for practical performance and support development of conceptual understanding in the context of practical activities, respectively. Finally, the ease with which MCTs and peer feedback assignments can be designed in learning management systems eliminates any obstacles related to the manual handling (handing out/collecting/distributing) of tests and assignments.

The time spent together with students in the teaching laboratory is very valuable and we consider it a criterion of success that we experience possibilities of discussing obtained results with students at higher levels of abstraction. For courses with limited degrees of freedom in learning activity design, this has proven to be one way to activate students prior to in-class activities with a beneficial outcome.

This model for structured preparation prior to laboratory activities is implemented as part of all experimental laboratory exercises in the bachelor program in Molecular Biology at Aarhus University from the summer of 2017.

References

Biggs, J. and C. Tang (2007). Teaching for quality learning at university : what the student does. Maidenhead, Open University Press.