ASIAN JOURNAL OF THE SCHOLARSHIP OF TEACHING AND LEARNING VOLUME 5 ■ NUMBER 2 ■ JUN 2015

COMMENTARY

Introducing research papers into a second year undergraduate Life Science module to promote active learning

Thilo HAGEN[1]

[1] Department of Biochemistry, Yong Loo Lin School of Medicine, National University of Singapore

Address for Correspondence: Assoc Prof Thilo Hagen, Department of Biochemistry, Yong Loo Lin School of Medicine, National University of Singapore, Block MD 7, 8 Medical Drive, #02-06, Singapore (117597)

Email: bchth@nus.edu.sg

Recommended citation:
Hagen, T. (2015). Introducing research papers into a second-year undergraduate Life Science module to promote active learning. *Asian Journal of the Scholarship of Teaching and Learning, 5*(2), 82-91.
https://doi.org/10.24112/ajsotl.53015

Introducing research papers into a second year undergraduate Life Science module to promote active learning

ABSTRACT

In large class university science courses, there is a great challenge to apply active learning methods and impart to the students essential skills in critical analysis and thinking, independent learning and problem solving. In this article, I describe an approach where traditional textbook-based teaching was systematically replaced by the use of research papers. In this approach, research papers were used for teaching, assignments and formal assessments. During the classes, important concepts were explained and then applied to real life research problems. In two assignments, students were required to read research papers independently and then apply the gained knowledge. The assignments included a commentary on a specific research paper, a drawn diagram on a disease pathway and most recently, a video assignment to describe a specific cellular aspect related to aging. In the formal assignments, students were given a specific research paper beforehand and then had to understand the content in detail. The actual assessment consisted of interpretation of research data derived from the paper. As a result of these changes, memorization was completely eliminated from the module. Based on individual student comments and a formal poll, the overwhelming majority of students felt that they had gained useful skills. Furthermore, the majority of students expressed that they preferred the research paper-based method of teaching and assessment over traditional lecture-based teaching. These outcomes show that even in large science classes, it is possible to engage the students in active learning. The skills obtained are likely to be advantageous for students during their subsequent modules and undergraduate research projects as well as in the long term preparation for their professional life.

INTRODUCTION

Lecturers teaching general Life Science core modules at universities face formidable challenges when trying to make teaching effective. These challenges include extraordinarily large class sizes - at NUS, typically 250 or more students. There is also a traditional emphasis on acquiring knowledge to build a strong foundation. This emphasis on transmitting knowledge is partly due to the constraints of the large class size and the current structure of life science core modules that is largely lecture-based. Consequently, modules in year 1 and year 2 are packed with large amounts of factual information that is transmitted through lectures and tested through continuous assessments and a final examination. In these assessments, the acquired knowledge of the students is tested through multiple choice and short answer questions. This approach

has several shortcomings. Most importantly, it makes it difficult to implement inquiry based and problem based learning and does not promote abilities in critical analysis and the development of independent critical thinking or other skills. But it is these aspects that have been shown to provide effective learning incentives, produce improved learning outcomes and equip students with essential skills to contribute effectively to our society (Hmelo-Silver, Duncan & Chinn, 2007; Freeman, 2014; Weiman, 2014).

A further problem with the current approach of life science teaching is that it gives students the wrong impression that scientific knowledge is static and that the majority of scientific questions have been solved. The truth is far from that, for as scientific knowledge evolves, it is constantly tested and reevaluated and the answers to many important scientific questions are unknown.

For these reasons, it is important to integrate into science modules more aspects that promote critical analysis, critical thinking and problem-based learning, to help students understand that science is a dynamic process that entails constant testing of hypotheses and revision of concepts. To address these desired learning outcomes, I have in the previous five semesters introduced a number of components that are based on research papers related to the lecture topic. The use of research papers is particularly useful because it not only addresses the above mentioned learning outcomes, but it also equips students with the skills to understand research data and illustrates the process through which we arrived at the current state of knowledge. Understanding research data is important because almost every future engagement of students in a science-related profession requires them to analyze and interpret scientific data.

In previous semesters, I have used research papers in a number of ways to achieve the desired learning outcomes. Firstly, the students were required to integrate research results and papers related to the pathogenesis of a human disease and draw a diagram illustrating the molecular mechanism of the disease. Secondly, the students were asked to write a commentary or news article based on a research paper related to the lecture material. Finally, for the continuous assessment and the final examination, the students were given one research paper related to the lecture topics beforehand. They had to understand the hypothesis, experimental approach and design and be able to interpret the experimental results and justify the conclusions drawn in the paper. In the assessments, all questions were directly related to the paper. In this article, I will describe the various research paper related approaches in detail and highlight the desired learning objectives. Subsequently, the outcomes will be discussed briefly, primarily based on the teacher feedback provided at the end of the semester and student poll results.

APPROACH 1: INTEGRATION OF RESEARCH DATA INTO A DIAGRAM DRAWING ASSIGNMENT

I am involved in teaching a second year life science module on cell biology in both

semesters, where I discuss cellular organelles and programmed cell death (apoptosis). Over the last five semesters, I have based the discussion of cell biology on understanding the pathogenesis of human diseases. Specifically, in my discussion of cellular organelles, I have focused on Parkinson's disease and discussed how the dysfunction of cellular organelles leads to the development of the disease. This approach has the advantage of making the lectures very applied and practical, which is generally appreciated by the students. It also provides a clear learning incentive for students to understand the molecular basis of a disease that they are made familiar with at the beginning of the lecture. Throughout the lectures, recent research findings on the pathogenesis of Parkinson's disease were presented and the underlying cell biology was explained. At the end of the discussion of the cellular basis of Parkinson's disease, the students were given two additional research papers that were not discussed in the lecture. Based on the research data presented in the lecture and the additional papers, the students were then given the task to draw a diagram depicting the mitochondrial quality control pathway which is defective in Parkinson's disease. For instance, in a typical assignment, the students were given the following task: "Draw a diagram that illustrates how Parkin and PINK[1] mediate the elimination of mitochondria that are damaged by mitochondrial complex I inhibitors (MPP+, rotenone)". Accomplishing this task required that the students understand the research findings, and process and synthesize the results to describe the organelle homeostasis that is disrupted in Parkinson's disease. It also allowed students to be creative and think of the most effective way to illustrate the pathway in a diagram drawing. The results were for the majority of students very impressive, in some cases truly astonishing, in terms of scientific excellence, artistic accomplishment and creativity. It was apparent that the students exhibited a high level of motivation that led many students to commit more time and effort to the task than was necessary to only obtain a good mark. In conclusion, the assignment enabled students to engage in critical thinking and to engage in independent, problem-based learning. It likely gave the students a sense of accomplishment as they gained in-depth understanding of a disease pathway.

APPROACH 2: WRITING OF A COMMENTARY BASED ON A RESEARCH PAPER

In a second assignment, the students were required to choose one out of four recent research papers closely related to the lecture topics. They then had to write a 1000- word commentary article that introduced the background of the research topic, described the major findings of the chosen paper and most importantly, provided comments on the research article. The students were instructed that their comments should give additional insights into the research topic. This could be in the form of a critical analysis of the research paper, highlighting important aspects or shortcomings of the study, or relating the work to other published studies, discussing potential applications or important future work. The writing assignment required that the students read and comprehend the research paper and independently acquire information necessary for

understanding of the paper. It also required independent research to find additional information in order to provide insightful comments as well as creative thinking to find ways to provide an interesting and illuminating perspective. Last but not least, it required good writing skills, an essential skill that is underrepresented in the current life science curriculum. It should also be mentioned that the format of the writing assignment, i.e. the writing of a commentary on a research paper, reduced the chances of plagiarism. In conclusion, this writing assignment promoted the development of a number of skills and abilities that are normally not covered in first or second year life science modules. The approach is likely more effective compared to learning from lecture material because it is problem-based and requires that students process new knowledge and synthesize what they have learned in the commentary. Finally, the approach familiarizes students with scientific research and the process of acquiring new knowledge.

APPROACH 3: ASSESSING STUDENT PERFORMANCE BASED ON UNDERSTANDING AND INTERPRETING OF RESEARCH PAPERS

For the continuous assessment and the final examination, the students were given two research papers (one paper for each assessment). The research papers were recent and closely related to the topics discussed throughout the lectures. Many concepts from the lectures were reiterated in the research paper while others were new to the students. The degree of difficulty varied, with the final examination paper being more challenging. Two hours of tutorial time was dedicated for the students to ask questions about the research paper data and interpretations. These tutorials were conducted in smaller groups of approximately 50 students to facilitate active student participation. It should also be mentioned that the papers were chosen by the lecturer at the beginning of the module. Thus, in order to prepare the students for the research paper challenges, the techniques and concepts of the papers were discussed in the lectures throughout the course of the module. Furthermore, the lectures also included frequent discussions of research results related to the lecture content. These discussions were usually interactive, whereby students first provided answers to a posed research-based problem (usually questions related to experimental design or data interpretation) through their class response systems (clickers). The problem was then discussed by the lecturer. For this task, I have also routinely involved members of my laboratory as teaching assistants. The teaching assistants applied concepts learned in the lecture by discussing their own or published research results using class response system technology. This interactive learning was highly appreciated in the feedback comments and many students felt that the use of the teaching assistants provided a more real-life experience of science. Taken together, these measures were likely to help students understand the research papers in the formal assignments.

The research paper-based continuous assessment and examination consisted of a series of 25 questions in true/false format and also included one additional short answer

question in the final examination. Compared to the common assessment format in 1st and 2nd year life science modules whereby students have to answer multiple choice and short answer questions based on the lecture material, the approach based on research papers has a number of advantages. Firstly, no memorization was required as the research findings (in the forms of the original figures with a figure legend) were provided in the examination paper. By answering the questions, the students had to demonstrate that they understood the specific research question and the various experimental approaches and were able to interpret the experimental results correctly. Based on the student feedback, it was also apparent that many students felt a sense of achievement to have managed to fully understand a research paper, which prior to the module was perceived as a very foreign and complicated task by most students.

OUTCOMES

The evaluation of the outcomes was based on verbal comments by the students given at the end of the semester and a poll conducted with students who took the module in the past. As part of the normal online feedback exercise by the Faculty of Science at National University of Singapore, students have the opportunity to provide teacher specific verbal feedback for the modules they took during the preceding semester. Based on these comments, the response to incorporating research papers into the module was highly positive. For instance, after completing the module during the second semester of Academic Year 2012/13, the most common positive feedback was that the use of research papers for the assignments and formal assessments resulted in a stress-free learning environment and eliminated the need for memorization of study material. Furthermore, out of approximately 250 students, 26 students stated that they liked the use of research papers while only 3 students had a negative opinion about their use. In the following semester the number of students who expressed that they liked the use of research papers was 37, while 7 students did not favor their use. Some of the comments by the students were that the use of the research papers helped them to develop important skills, required them to apply what they have learned and promoted independent learning and critical thinking.

In order to obtain a more quantitative measure of the perception of the students, two polls were conducted with life science students who are currently in their third and their fourth (and final) year of study (both groups took the module during their second year) (Fig.1). The response rates were approximately 40% for the year 3 students and 27% for the year 4 students. The students were asked to indicate to which degree they agreed with two statements on a scale of 1 to 5. According to the first poll, an overwhelming number of students felt that the various module components that employed research papers provided them with useful skills. When combining response 4/5 and 5/5 and response 1/5 and 2/5 in Fig.1 (top panel), 79% of year 3 students agreed with the statement and 8% disagreed. Year 4 students gave a similar response (80.5% agreed and 7% disagreed with the statement). Notably, based on the second poll there

was also a majority of students who preferred the use of research papers as a teaching and assessment method over traditional textbook-based teaching and assessment. Thus, 61% of year 3 students and 58% of year 4 students agreed with the statement while 17% and 14%, respectively, disagreed.

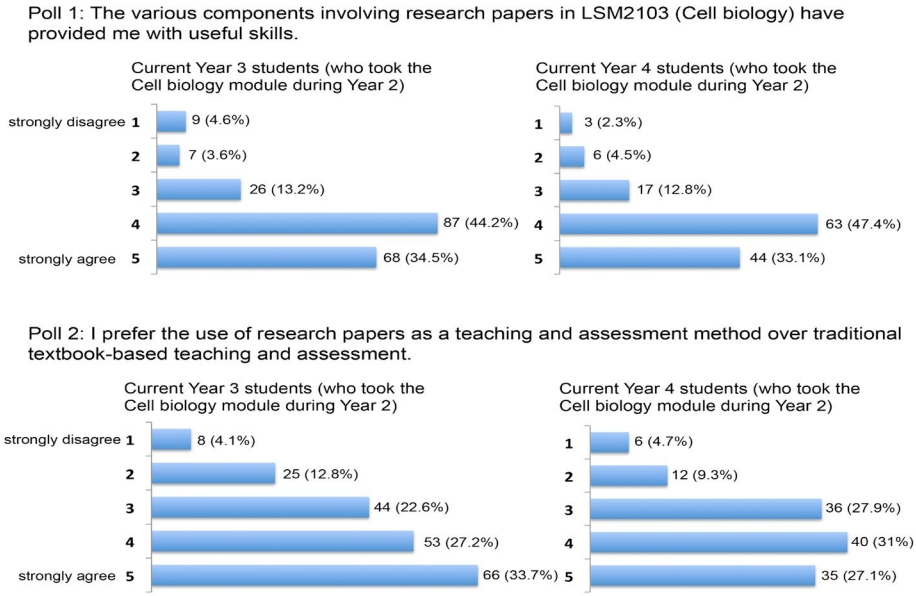

Fig.1 Polls conducted with two life science cohorts at the National University of Singapore. The surveys were conducted using the freeonlinesurveys.com platform. The response rates were approximately 40% for year 3 and 27% for year 4 students.

A recent article has described a similar approach integrating research paper reading into life science modules (Yeong, 2013). In the approach used, the author implemented a flipped classroom strategy whereby the students were asked to read a research paper on a topic related to the lecture. The students then had to write an essay in which they had to explain the concept discussed in the paper. The verbal feedback of the students was overall very good, with many students commenting that they had learned valuable skills. The acquisition of important skills in independent learning and critical thinking was also reflected in a survey conducted after the assignment. In the survey, 26% of the students indicated that they preferred reading the research paper over listening to a lecture on the specific topic. The even higher preference for using research papers (61% and 58% in year 3 and year 4 students, respectively) in this study may be due to a number of reasons. While the feedback in Yeong (2013) was collected at the end of the semester, the feedback in this study was obtained one or two years after the students took the module. This likely gave the students more time to realise the benefits of the research paper-based approach in their further studies. Furthermore, in the approach described in this article, the use of research papers

was systematic, covering a large part of the module, encompassing both teaching and assessment. As a result, the use of research papers replaced traditional teaching and was less likely to be viewed as an additional burden by the students. Indeed, the fact that the research paper-based critical analysis type of assessment replaced the usual memorization-based testing of knowledge was explicitly stated as positive by many students. The repeated exposure to research papers (students had to study 5 articles in detail over the course of the module) also made it easier for the students to understand the experimental approaches and writing style.

There are a few aspects that I believe are important to the successful use of research papers in basic science modules. Firstly, it is essential to familiarize the students with the research methodology used in the research papers. To this end, lecture time was devoted to explaining essential cell biology experimental techniques and to letting the students interpret research data obtained using these techniques. This was done using questions that the students answered using their class response systems or through in-class-discussions, whereby the students used a portable microphone to respond to questions from the lecturer (Deslauriers, Schelew & Wieman, 2011). Secondly, another important aspect is that clear instructions are necessary for the research paper based assignments. For instance, in preparation for the research paper based commentary, I devoted 45 minutes of lecture time to discuss with the students the structure and content of a commentary as well as important points with regards to writing approach and technique. This was also done in an interactive manner to promote better assimilation of the provided guidelines.

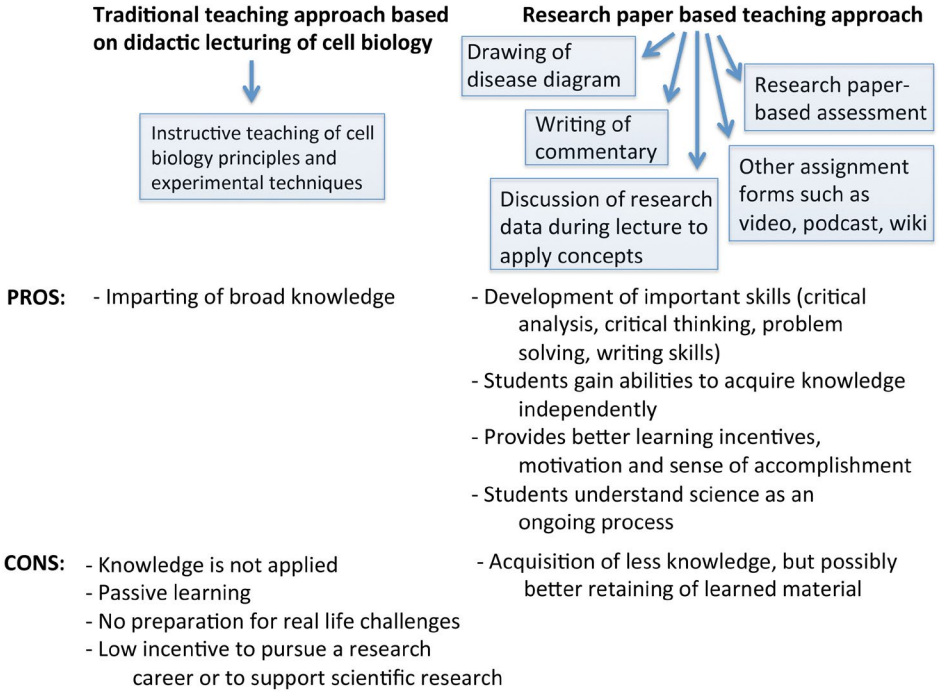

Fig.2 Comparison of format and outcomes of traditional lecture-based and research paper-based teaching of cell biology.

CONCLUSION

In conclusion, the introduction of research papers into the year 2 cell biology module has had a positive effect on student learning and has helped me to achieve learning outcomes that I was unable to accomplish with the traditional lecture approach (as summarized in Fig.2). These learning objectives include the acquisition of important skills such as understanding and critically analyzing scientific data, independent problem solving and developing the ability to write. In addition, I believe that the active engagement of students with science increased their interest and passion in the topic and imparted to the students the concept that science is an ongoing process.

REFERENCES

Deslauriers, L., Schelew, E., Wieman, C (2011). Improved learning in a large-enrollment physics class. *Science*, 332, 862-864.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P (2014). *Active learning increases student performance in science, engineering, and mathematics*. Proc Natl Acad Sci USA, 111, 8410–8415.

Hmelo-Silver, C. E., Duncan, R. G. , & Chinn, C.A (2007). Scaffolding and achievement in problem-based and inquiry learning. *Educational Psychologist*, 42, 99–107.

Wieman, C. E (2014). *Large-scale comparison of science teaching methods sends clear message*. Proc Natl Acad Sci USA, 111, 8319–8320.

Yeong, F. M. (2013) Using primary-literature-based assessments to highlight connections between sub-topics in cell biology. *Asian Journal of the Scholarship of Teaching and Learning*, *3*(1), 34-48.