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Effect of research based teaching on student learning and motivation

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Introduction

Effective teaching at university level requires a great deal of research related activities. This is a common belief among both politicians and academics who design strategies for optimizing the teaching at university level (Webster 1986). Teaching and research are often viewed as mutually supportive and indistinguishable in a dynamic and fruitful university environment. This view is not surprising since both activities form a cycle where new scientists are trained to discover new science which in turn is transmitted to the next generation of scientists.

However, recent research trying to map the correlations between research and teaching has not supported the above general belief that research-based teaching results in enhanced student learning. In fact, most investigations have revealed a zero or minimal positive correlation between including research in teaching and the effect on learning (Hattie 1996). This surprising finding is very important and should lead us to consider why and how we should employ current research in the class room. If no positive outcome results from including research in teaching we should not bother spending the time on activities that might need a significant effort from both the student and the teacher. However, although no positive correlation exists between research and teaching in academia these investigations might not have distinguished between particular elements in the research-teaching relation and the result may therefore be a convolution of several factors contributing negatively and positively to learning outcome.

Students do appreciate having teachers who present research conducted by themselves which gives the material some authenticity compared with presenting some facts from a book. Also, researchers who actively pursue new knowledge have a critical view on science and can demonstrate to the student that new research findings are often contested for a long time before being accepted as facts or even modified before being accepted as facts. Moreover, nobody would deny that a devoted researcher presenting exciting cutting edge research (even if it is disputable) would enhance motivation and curiosity in many students. These positive effects are not easily measurable on a grade scale but should not be underestimated since they give the student the endurance to stay motivated and finish his or her education whereas a good grade merely gives a brief satisfaction to the student.

On the negative side of the research-teaching relation we can imagine that some researchers spend a lot of time on research and consequently give lower priority to their teaching responsibilities. In fact a negative relation has been measured between the time spent on teaching and time spent on research (Olson & Simmons 1996). Researchers do not get much credit for improving their teaching but instead can improve their career by publishing important research findings. This poses an obvious challenge to universities and makes research and teaching competing activities instead of mutually supportive activities.

In this project I have tried to test the effect of including research in my own university teaching. The aim was to elucidate the effect of three different activities on the learning process and to test the motivational effect of these activities on the students. The outcome of these activities would be monitored in the exam, where I was an examiner myself, and also I used an evaluation scheme in which the students could express their opinion about the three research activities. The course was an introductory course in biophysics with eighteen students who also attended the exam.

Research based learning activities

First activity mandatory project

I designed a research related project which was mandatory to pass in order to register for the exam. The project involved reading a recently published paper about membrane-curvature generation of proteins (Heinrich et al. 2010). The paper is relatively easy to understand and contains some

equations which the students have the background to understand. Although the scientific level was not too complex the paper is interesting and has a central place in literature regarding the membrane-curvature generation of proteins. Moreover, the content of the paper overlapped significantly with the curriculum. Experimental techniques used in the paper were a part of the curriculum and also topics like bio-membranes and the concept of diffusion were heavily treated in the paper as well in the course text book.

Papers can be quite hard to read for undergraduate students who are only used to textbooks that contain all the necessary background information and only treat material relevant for a course. Therefore it was important to assist the students in approaching the project by defining questions and points that were important for the curriculum. The students were asked to give a summary of the paper with emphasis on certain points which were given in the assignment. To assist the students in focusing on the essential parts of the paper, a set of questions were defined where the student should explain the functioning of an experimental technique or perform some relevant calculations.

The devolution of the project was also accompanied by a lecture held by a researcher who worked with exactly the same scientific problem as in the project paper. Also, in conjunction with the project, a visit to our lab showed the students how we conduct experiments similar to those described in the paper, and the students were allowed to play around a little with the equipment.

Finally, the students were allowed to ask questions and discuss the project with the teachers of the course (myself, the course responsible and the instructor) for four hours. This way we could eliminate any confusion and misunderstanding that had occurred for several of the students.

A total of eighteen students handed in the project work and all eighteen projects were very well answered. Even though the projects were not graded some of them far exceeded any expectations I had. My impression was that the students liked the project and found it interesting to work with real science instead of just reading a standard text book. During the question hours I also received direct feedback from students saying that the project-paper was really interesting to read and work with.

Second activity: paper presentations

To train the students in critically reading scientific papers the students were asked to present a paper for their fellow students. Moreover, a few of the

students should act as peers and prepare questions to ask the presenter and hopefully initiate a discussion.

This activity was a mixed success. The chosen papers had very different levels and their relevance to the curriculum differed somewhat. The first paper was very old and the formalism was hard to understand. This resulted in little discussion and the students seemed uninterested and frustrated by this paper. However, the other two papers were more up-to-date and seemed to catch the interest of the students which resulted in more lively discussions.

Third activity: guest lecturers

Finally, researchers were invited in to give brief talks about their research. Again to enhance learning the researchers were chosen such that their research overlapped with the curriculum. The topics included X-rays of proteins, and two lectures about membrane physics with two very different scopes. This activity was generally very passive for the students. In two of the lectures the students seemed tired and the level of the lectures appeared too high. However, in the one of the lectures, about bio-membranes, the students were very interested mainly because the lecturer was able to give the students the impression that all current knowledge about the topic was potentially incorrect despite several Nobel Prizes having been given for the discoveries. This triggered a lot of questions from the students and the lecture went forty-five minutes overtime due to students interrupting with questions.

Evaluation of activities

To gain insight into the effect of the research based activities on learning and motivation the students received a questionnaire where they were asked to evaluate (1) the level of all the activities, (2) the effect on learning and (3) the motivational factor. The questions are listed in the appendix.

A total of sixteen students handed in the questionnaire and the answers are summarized in figure 14.1.

The overall impression of the activities was very positive. In particular the project was a success according to the students: fifteen out of sixteen students stated that the project strongly supported learning (Fig. 14.1B) and all students rated the project as inspiring or somewhat inspiring (Fig. 14.1C). In the evaluation scheme the students could give optional comments

about the activities. Several students wrote explicitly that the project was highly interesting and had stimulated their learning. A couple of examples:

> "I learned most from the project, because we had to work with it for a longer period of time; would have liked two small projects just because I learned most from it, and the articles and lectures were just listening."
> "The mandatory project was awesome."

The success of the project was also consistent with the student's perception of the level of difficulty: fourteen out of sixteen students answered "not too difficult", see figure 14.1A, and one student thought it was easy.

The other two activities were also perceived as supporting the learning process but to a lesser degree. These activities were more appreciated with regard to the inspirational value which was emphasized in the evaluation (Fig. 14.1) and also in the general comments:

> "The research in teaching made me interested in specific parts of the subject and that I've got an overview of how we can use biophysics is really what is amazing"

Almost 50 % of the students thought the guest lectures were too difficult which was also apparent in many of the general comments. However, many of the comments were ambivalent towards the guest lecturers since they were difficult to understand but at the same time the students felt inspired or motivated by the authenticity of a researcher talking about current research.

Notably, none of the activities were perceived as not inspiring by any student (Fig. 14.1C). This agreed well with my initial hypothesis that the students should at least be inspired by working with and hearing about front line research topics from researchers themselves. The overall impression was also positive as shown in figure 14.1D, since all students rated the activities as inspiring or educational. In a final question, the students were asked if they would recommend us to include these activities in future versions of this course and 100 % of the students answered yes.

Discussion

The evaluation was extremely positive but the question remains whether the activity actually supported the student's learning process or merely gave them a satisfaction from working with and hearing about research.

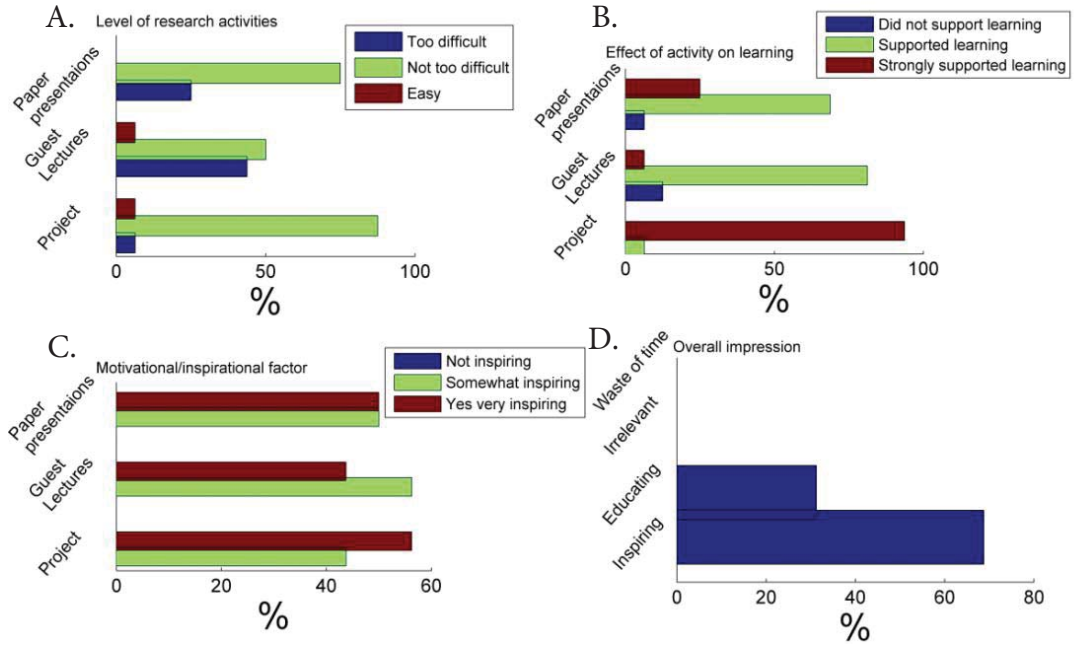


Fig. 14.1. Answers from the students to the questionnaire about the research based activities. A. The level of the three research activities was ranked as three levels of difficulty as shown in the legend. B. The students answered to which degree the particular activity supported learning. C. Evaluation of the motivational and inspirational factor of each activity. D. Finally, the students gave their overall impression was of the activity with four options from inspiring to waste of time.

All the research seems to indicate that students learn best when the teaching is student centred (Biggs & Tang 2007). The research based activities in this course had different degrees of student involvement; the paper presentations were more or less left to the students with a few comments from the teacher along the way or afterwards. The project was highly student centered with the teacher assisting the students but the time spent on this assistance was limited. In contrast, the guest lecturers were highly teacher centered since the students were listening but since the atmosphere was relaxed many students also asked questions which often led to open discussions led by the lecturer.

A framework has been put forward by Griffiths and Healey (Griffiths 2004, Healey 2005) in which research in teaching can be classified into four sub-categories: (1) research tutored, (2) research led (3) research based and (4) research oriented. The framework is sketched in the diagram in figure 14.2.

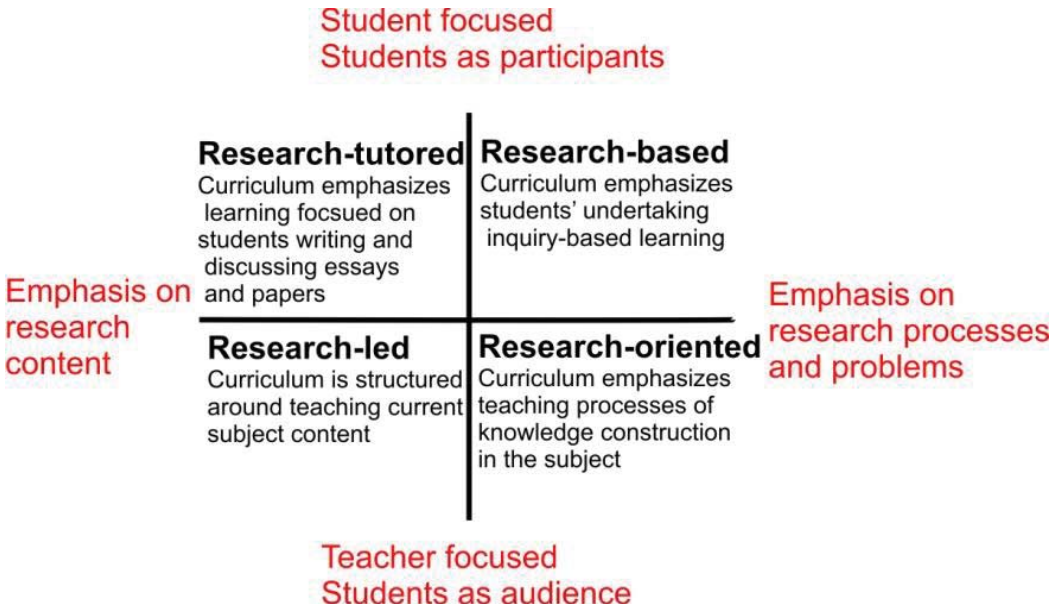


Fig. 14.2. Teaching-research nexus by Griffith and Healey.

Effective learning would include all four parts in figure 14.2 but the emphasis should be on the approaches in the top half of figure 14.2 since here the student is actively participating in the learning process. According to the definition in figure 14.2 the research tutored and research based teaching are highly student centred whereas the research led and research oriented are more teacher centred and the students act more as a passive audience.

The three research activities included in this course cover all four types of the research–teaching nexus presented in figure 14.2. The guest lecturers, being focused on the research and research process and with students as audience clearly belong to the lower half in figure 14.2. In contrast, the mandatory project was highly student centered since it made students look for information, solve problems, ask questions, read a scientific paper and write up their conclusions. Therefore, the project belongs in the top half of figure 14.2. Finally, the paper presentations were also student centred since they included reading, presenting and discussion of papers by the students, mainly, and therefore this activity was research tutored belonging mostly in the top right in figure 14.2.

Conclusion

The effect on learning from the three research activities was clearly most significant for the project work, a conclusion which was drawn from the evaluation of the activities by the students. This activity clearly was the most student-centred and activated the students much more than did the guest lectures or paper presentations which only activated a few of the students. The students' perception of learning was also backed up by my own observations from the exam where I could see that even the weak students knew all the details regarding the subjects discussed in the project.

The learning outcome is only one factor important in teaching, however. Inspirational value and becoming motivated to continue learning more about the subject matter should not be underestimated; with regard to this factor, all the activities scored very high in the evaluation. Moreover, all the students recommended such activities to be included in future versions of this course. This confirms my belief that including research activities in teaching can be fruitful, but they should be carefully designed to motivate and activate students to enhance student learning. Also, the topics should be directly overlapping or relevant to the curriculum to justify the use of these research activities in teaching.

A Questionnaire for the Course: Introduction to Biophysics

I would very much appreciate if you could tell me your opinion about the research based activities which you have been exposed to during this course .

Research related activities:

- Mandatory project based on current research (Curvature generation of N-BAR)
- Three star lectures where research was presented about:
  -X-Rays
  -Tubes and curvature sensing of F-BAR
  -Membrane biophysics
- Paper presentations
- And a single visit to our lab showing how we conduct biophysical experiments

Please mark your answer with a cross below:

1) How was the level of the mandatory project?

Too difficult____ Not too difficult ____ Easy____

2) Did the mandatory project support the learning process?

Did not support learning___ Supported learning____ Strongly supported learning____

3) Did you find the mandatory project inspiring/motivating/interesting?
No____ Yes to some degree____ Yes very much____

4) How was the level of the Star lectures?

Too difficult to understand____ Not too difficult ____ Easy____

5) How did the star lectures support the learning process?

Did not support learning___ Supported learning____ Strongly supported learning____

6) Did you find the star lectures inspiring/motivating/interesting?

No____ Yes to some degree____ Yes___

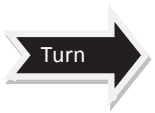
7) How was the level of the papers?

Too difficult to understand____ Not too difficult ____ Easy____

8) Did the papers support the learning process?

Did not support learning___ Supported learning____ Strongly supported learning____

9) Did you find the papers inspiring/motivating/interesting?
No____ Yes____ Only one or two of them____



Did you find the overall effect of the research based activities to be:

Inspiring ____ Educating ____ Irrelevant ____ Waste of time____

Would you recommend us to include these kind of research based activities in this course in the future?

Yes____ No____ Don't know____

If you have any additional comments about the research activities you are most welcome to write them below (e.g. what is good or bad with research in teaching?):

Comments:

Thanks in advance

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