
The Research-Teaching Nexus: Ideas and a case description

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Broad discipline area:

- Mathematics, but many of the ideas have more general applicability

Year level:

- Third year undergraduate, has also been used to some extent in second year

TRN strategy:

- Drawing on personal research in designing and teaching courses
- Designing learning activities around contemporary research issues and/or more advanced ideas than is usual
- Building small scale research activities into undergraduate assignments
- Infusing teaching with the values of research

Teaching and learning context:

- Third year class of 10-18 students
- Strong emphasis on oral, visual and written presentations by students to the whole class
- Curriculum design to make course content and student presentations possible with material at a more advanced level, with an emphasis on independent thought and research
- Assessment based on participation and assignments, plus conventional exam

Brief description of the initiative:

The description has two parts: I. Background and II. Implementation.

1. BACKGROUND

There are various ways in which one might try and incorporate research and/or more advanced material than is customary into teaching, with a view to increasing student interest, and encouraging independent thought and intellectual autonomy. The ways mentioned below are intended to be neither exhaustive nor exclusive**;** they can overlap and can be used to various degrees and in various combinations.

I.1. The content-based way

This is perhaps the most obvious approach. One way a teacher can incorporate research into teaching is by simply alluding to recent or current research, or by giving a factual description of it, at various times during the teaching of the subject. Such an approach can be essentially superficial. If the research is merely mentioned in a factual way, in the same way as the main part of the subject matter may be mentioned, it won't necessarily convey anything of the feeling of enquiry and the desire for new knowledge that motivates the serious researcher. Nevertheless, even in unpromising circumstances, this approach can potentially change the perception of the subject material by the student. Incorporating recent research or more advanced material than customary into teaching, even in a merely allusive or factual way, may convey, simply by its very *contemporaneity*, a feeling of discovery for the student, and of possibilities for creating new knowledge. Of course, this way might also include results of partially completed research ideas and projects, with indications of further lines of research.

The extent to which the content-based incorporation of research into teaching is possible depends upon circumstances in the discipline. It is more likely to be possible in the social sciences or education, for example, than in mathematics or physics. In mathematics, with its very tight logical, linear structure, there is generally a huge gap between current or recent research and the material of the undergraduate curriculum.

I.2 The attitude-based way

Rather than incorporating specific content, the teacher may try and convey a research attitude in their teaching –through teaching by enquiry; the latter involving the teacher alone, or the teacher and students together. The aim is to instil an attitude of independent enquiry and intellectual self-reliance in the student. In this approach, the nature of the material taught is largely irrelevant, except to the extent that it lends itself to the openness of this approach, and is not merely items of information to be noted and memorized for future use. It is more difficult to carry out in fields where content, as traditionally conceived, dominates. This approach may be implemented in various ways, but as a method it is ancient, and goes back to Socrates, as in such Platonic dialogues as The Meno.

I.3 The synthetic or "bridge-building" way.

This is a possible approach when circumstances make it very difficult to incorporate research as described in the content-based approach. It aims to create a synthesis between the content-based and attitude-based approaches. It aims to "build bridges" between the world of research and more advanced ideas, and the actual undergraduate teaching situation. However, in doing this, it goes beyond simply using each of the above approaches separately, especially in its attempt to re-think older ideas, or recent research ideas, so as to make them accessible in a way that would otherwise not be possible. To do this, it may need to simplify the ideas and the technical tools for discussion of them to a specific, less general, situation. Depending upon the circumstances, this can be a very challenging and time-consuming task.

II. A SPECIFIC IMPLEMENTATION

The synthetic, bridge-building approach was used in a third year mathematics class in topology and chaos theory. Course material was specially prepared in units, each unit being about 1-3 pages of printed material. The idea was that the students, either singly or together, would present the units to the class over the teaching period. This was to occur to the greatest extent possible, with the lecturer(s) providing help in introducing ideas and linking material that arose and that was beyond the students' knowledge to discuss adequately.

A large part of the material dealt with topics that were not normally accessible at the third year mathematical level. This was made possible by re-thinking the material, so that the strictly logical and linear patterns of reasoning imposed by mathematics as a discipline were preserved, but the background generally assumed to be necessary to study this material was substantially reduced, or even eliminated. Although the students are not necessarily explicitly aware of it, an effect of the approach is to provide a much more contemporaneous feeling about the subject material, and a greater involvement with it.

The re-thinking of fundamental ideas, and the emphasis on presentations, meant that students in the subject were able to learn in a more research-orientated way, in relation to both content and style of learning, despite the obstacles due to the nature of the discipline. It made it possible for students, in effect, to give the lectures in certain topics, and in topics at a higher level than usual. The fact that students had to present their own ideas meant that a greater mastery of the material was needed than is required by routine teaching and assessment. Explanation and the elucidation of ideas always requires a deeper understanding and competence than usually results from only listening. So, in effect, the students provided a proper *understanding* of the ideas, as distinct from a mere *formal competence* with the ideas – a fundamental issue in mathematical pedagogy. For some students, it created a new perception of the nature of mathematics and the wider applicability of its thinking methods – and they are methods that extend far beyond the discipline itself. In some years, students have presented up to 70% of the course material. The approach works better when two staff members work as a teaching team, providing different points of view on the material, and interacting with each other and with the students.

The approach created demands on the students – the fact that they had to present their own ideas about the material imposed a substantial preparation time on them, and the fact that they have to present in public added to the demands. It also added, in some cases, to student anxiety for shy students and/or for students with English language difficulties. Concerning the presentations, the students were assessed on their willingness to participate, rather than on the standard actually attained – the idea was to reduce any stress associated with presentations, and free up the students emotionally so that they could discuss their ideas openly without fear of a penalty if the ideas turned out to be ill-founded or mistaken. The approach was intended to open up possibilities for discussion and exploration, and to create a fear free environment for the discussion of ideas – and in mathematics, where the intellectual demands are very clear, the creation of a fear free environment is a goal of pedagogical importance.

Students can be more prepared to ask questions and participate when the content is being discussed by a fellow student – the atmosphere of the class can change from being one where the students learn *from* someone, to where all are *learning together*. When this happens, it heightens the learning experience.

Based upon observations and informal student feedback, students seemed to have gained a deeper, more lasting and many-sided view of the material. One of the factors here was that apart from the presentations, students often helped or made suggestions to the person presenting. It also developed students' awareness of different ways of presenting ideas by means, of powerpoint (say), transparencies, handouts, interaction with others, and solutions worked at the board. It also gave them a greater experience of the development of ideas at both the individual and collaborative levels.

The approach also had disadvantages. The main one was that from a technical point of view, not as much material was covered. We see this as inevitable, for the students took longer to explain the ideas than a lecturer would, in general, and were often feeling their way with ideas which were totally new to them. But of course, it is precisely because they were feeling their way with the ideas that gave this method its distinctive feeling of genuine enquiry and research. The issue faced is a very individual one for the teacher – the question of the balance between a pedagogy concerned with the student as a whole person, and a pedagogy concerned with mere information acquisition.

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