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Cooperative Problem Based Learning and Content Coverage:

Experiences in Physics

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Problem-Based Learning (PBL) is a teaching methodology that pursues active and cooperative learning. Rather than taking in information through listening to the teacher lecture, the students in a PBL class must take control of their own learning both as individuals and as a team. The approach is simple: students are presented with complex, real-world, open-ended problems and learning is achieved by identifying, researching, and elaborating upon such material in a group.

While PBL has met with much success in recent years, there are still many difficulties in using the method, in particular in upper division classes where complexity is high and the time required for PBL activities is a liability. The difficulties inherent in the method, however, need not spell out the doom of its application to such classes. What follows is a case study of a solid state physics class (PHY 556) which was taught to majors and graduate students using a modified PBL method. Our experiences might provide some insight for others into how PBL might be applied to other upper division courses.

The format of this class was designed to successfully utilize the PBL approach while still being able to cover advanced material in a thorough way. Because the students are required to find their own resources to consult, as well as organize and use the information that they find, it takes considerably more time to go through a PBL activity than to learn through lecture. Due largely to the complexity and variety of the material at hand, this is an even greater trouble in upper division classes. As such, the format of instruction was designed to account for this. Each unit was presented in eight steps, as follows:

Step 1: Presentation of a problem in general terms by the instructor.

The first step in any PBL activity, this was used to introduce the topic at hand and stimulate discussion within the groups. The problem presented was complex and chosen to involve many of the concepts to be elaborated upon in the unit to follow.

Step 2: Group work to formulate appropriate learning issues (LIs).

Once again, this follows the traditional style of PBL. After the groups had read the problem, they discussed amongst themselves what information was needed in order to make sense of it. This information could range from factual information to understanding of concepts involved. These were formulated as questions about the subject and written down as 'learning issues.' The purpose of this exercise was to get the students to think specifically about what it is that they know, and what it is that they need to learn.

Step 3: Individual research on the formulated LIs.

Once the questions were formulated in step 2, the students divided them up and researched them in any way they could. This was done outside of class time, and organization of the research was left entirely up to the students.

Step 4: Quiz in class on the research performed to address the LIs.

After the learning issues had been researched, a quiz was given in class to assess the quality and depth of the research done by the students. The quiz was taken in groups.

Step 5: Micro-Lectures on the LIs.

Using the results of the quiz from step 4, the instructor then put together a series of lectures to elaborate upon the research already done by the students. This step represents the furthest departure from the traditional PBL method, as a concession to coverage, and to keep the class moving forward.

Step 6: Group work to prepare a report and a concept map.

After the material had been elaborated upon in step 5, the students were then responsible to (within their groups) organize and draw connections between the various subjects covered, in the form of a report and a concept map.

Step 7: In-class assignment on the micro-lectures.

In essence, a test, given individually to assess what the students had learned.

Step 8: Group assignment on a related topic.

Now that the students had covered the material, another assignment was given much like what was given in step 1. The aim of this assignment, however, was not to help the students to identify what they needed to know, but to apply what they had learned to a more complex situation. Ideally, this assignment would minimally involve concepts to be studied in the following unit. This step forces the students to apply what they have learned to a new and different situation from those which have been studied (this may be taken as a definition of learning itself).

Our first unit (to use it as an illustration of these steps) began with the problem of the hydrogen spectrum, and the inability of classical physics to properly explain it (step 1). From there, the groups of students met amongst themselves and discussed what they needed to know to explain this (step 2), and looked up the information that they needed (step 3). A quiz followed the next day in class (step 4), followed by a few days of lecturing on the subject (step 5). Once the lectures were over, the groups prepared a concept map and report summarizing the subject at hand (step 6), which was turned in on the day of the exam (step 7). An assignment was given out after the exam, which required the students to use what they had studied in order to find the spectrum of a hypothetical 1- and 2-dimensional hydrogen atom (step 8).

Overall, the experience was quite successful. The material was covered, and in at least as much depth as in a standard lecture course. Step 8 in particular provided an excellent bridge between subjects, and provided the students with both challenge and insight into applications of the subjects they have already studied. The groups worked very well together, and the groups reported that discussions were very helpful.

It is worth noting that care must be taken when teaching such a course, that the range of the students exposure must align with what is expected of them. Problem-Based Learning problems tend to be quite qualitative and open, which works well to teach concepts. However, if the students are expected to be able to solve qualitative problems, as well, it is important to provide adequate resources and instruction towards that goal. This is especially true in mathematics and sciences: concepts are generally more important than quantitative skill in these fields, but quantitative skills cannot be ignored either.

Problem-Based Learning has met with much success in undergraduate education, as it closely mimics the 'natural' way that people learn: through observing real world examples. It mirrors exactly how new discoveries and theories are made in both the most basic and most complicated subjects. It is our hope that this case study might provide insight and inspiration about how this method of instruction might be applied to various classes, across all levels of difficulty.

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