Pilot Hole Approach with Partially Flipped Classroom

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Abstract

Engineering courses can be divided into two categories: theory-intensive and practice-intensive courses. For the courses in the second category, students cannot learn the knowledge and skills effectively without doing homework assignments. However, because the solution manuals are widely available, and many students take this shortcut approach. In order to prevent students screwing up, a pilot hole approach can be adopted. After a homework is assigned, a portion of class time is used for students to work on these problems in small groups. During this short practice session, students can figure out the ways to solve the problems through discussions. This practice session serves just like a pilot hole in carpentry, which can provide the guidance for the screws. Compared with the approach of a fully-flipped classroom, this partially-flipped approach can strike a balance between teaching and practice. In general, 60-80% of class time is used for teaching, and 20-40% of class time is reserved for the practice sessions. In this way, it does not undermine the lecture component significantly. At the end of the semester, students completed a survey on this approach, and the result was quite encouraging. In addition, from the messages left in the course evaluation at the end of the semester, students revealed that working on the homework problems was very helpful for them to understand the concepts.

Introduction

In many engineering programs, students need to learn both physics and engineering courses. The emphasis of many engineering courses is on problem solving, rather than understanding fundamental laws in nature as in the physics courses. Debates on the effectiveness of traditional homework in engineering education occurred [1-4], but the overwhelming majority of engineering faculty members believe that homework is an indispensable component in the courses they teach. As an analogy, students majoring in English need to write many essays for practice, and they cannot master the skill of writing just by learning various writing skills and reading novels. In the same way, engineering students cannot grasp the necessary knowledge and skills without the struggling process in solving homework problems [5].

Almost all the publishers of the textbooks provide the solution manuals to the instructors, and unfortunately, these materials are leaked to students through the internet. Some websites even invite students to provide quiz and exam problems, which can be used by students taking the same courses in the future. Just like the process of learning any set of skills, there is a period of struggle at the beginning. This process is considered very frustrating for many students in the generation Z who are used to finding answers easily by googling. Therefore, solution manuals are widely used, and many students take this shortcut and bypass the challenges in problem

solving. After doing homework in this way for a couple of semesters, some students already developed a bad habit that is hard to rectify.

Research results show that this behavior has detrimental effects on students' learning [6-7]. In order to avoid this problem, a few different approaches have been proposed and adopted [8], such as the flipped classroom [9] and individualized homework problems assignment [10], etc. For lower level courses, online homework management systems are very effective, and some textbook publishers also provide test banks [11]. In the past we also developed different approaches in dealing with this problem, such as involving students in problem design [12].

Pilot Hole Approach

In engineering curricula, the advanced courses are based on the fundamental ones. Therefore, if some students cannot learn basic knowledge and skills well in lower level courses, they will encounter greater challenges later, and it is more likely for them to drop out of the engineering programs. Therefore, it is very important to cultivate a healthy learning style at the beginning of the degree programs. For electrical engineering majors, Circuit Analysis is a basic course, so we adopted a "pilot hole approach" for this course.

In carpentry, it is not easy to drive a screw straight down into a piece of hardwood, and thus a pilot hole can be drilled first for guidance. In addition, it can also effectively prevent the wood from splitting while driving in the screw. This technique can be transferred to teaching engineering courses: After a homework is assigned, at the end of the lecture the instructor can give students 20 - 30 minutes to work on these problems in small groups. During this short practice session, students are instructed to discuss and write down the strategy to solve the problems in a defined format before beginning any actual solutions. This discussion enables everyone to at least understand what needs to be done to solve the problems because students usually are not able to solve all the problems assigned completely. After the class, students should be able to complete the solutions by themselves. Because these problems are already half-solved and the methods are identified in the class, students are less likely to abandon their work and copy from the solution manual. Compared with the approach of a fully-flipped classroom, this pilot hole approach can strike a balance between teaching and practice. In general, 60-80% of class time is used for teaching, and 20-40% of class time is reserved for the practice sessions. With the number of example problems reduced a little during lectures, the coverage of content can be kept basically the same as with a traditional approach.

Assessment

In most Electrical Engineering programs, Circuits Analysis is a two-semester course with a lab component. However, due to the diversity of the students' degree programs in our department, we cover most of the content in the textbook (David Irwin and Mark Nelms) in one semester, which is a four-credit-hour course without a lab component. Therefore, it is an intensive course with a rapid pace, and many students feel that it is quite challenging to solve the homework

problems at the beginning. In addition, most students do not understand some concepts easily, since there is no opportunity for them to play with the circuits in the lab.

The pilot hole approach was adopted in Spring 2018 for Circuit Analysis course, and students completed a survey at the end of the semester. The thirteen students enrolled in this course are from different degree programs: 1 CpE, 3 EE, 6 ME, 1 Physics, and 2 in the pre-engineering program. There were three questions related to this new approach: (a) How often do you need to use the solution manual in completing homework assignments? (b) Is the exercise session helpful in doing the homework assignments? (c) If there were no exercise sessions, would you become more dependent on the solution manual? For each question there were five options: (1) 0-20%, (2) 20-40%, (3) 40-60%, (4) 60-80%, (5) 80-100%. The results of percentage of students are shown in Figure 1 below. The numbers along the horizontal axis are the five options described above. The column heights in the figure indicate the percentage of students who selected the specific options. Since the highest column is at 37.5%, the maximum in vertical scale is set at 40%.

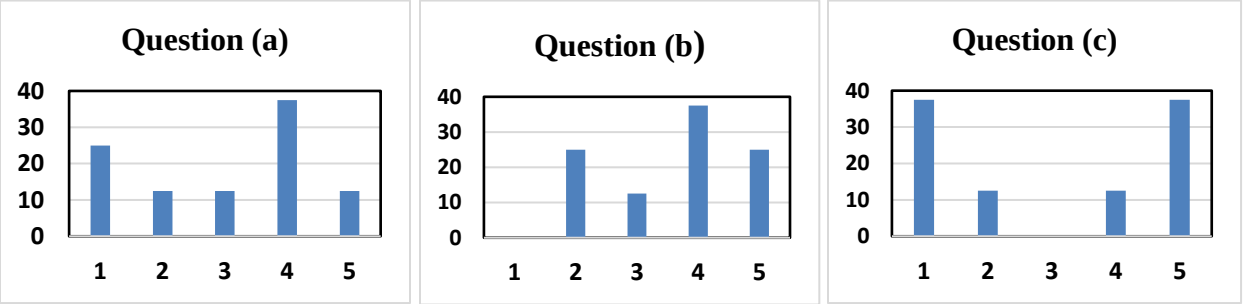

Fig. 1 Survey results.

The answers to survey question (a) indicate that there is a bifurcation in solution manual use: 37.5% of the students seldom use it (the two columns on the left side combined), while 50% of the students use it regularly (the two columns on the right side combined). The answers to question (b) show that no student considers the exercise session useless (missing column at #1), and 63.5% of the students consider it very useful (columns at #4 and #5 combined). The answers to survey question (c) display a bifurcation again: half of the students became less dependent on using the solution manual with this pilot hole approach, while there was not much effect for the other half of the students who did not have a strong dependence anyway. This result is very encouraging, since the cost of this approach is very low, and it can be adopted in most engineering courses.

In the class evaluation at the end of the semester, students left some feedback messages on learning this course. One student wrote: "*Conceptually difficult, hard transitioning between the lecture, which was conceptually focused, and the homework, which was application focused*." This message implied that there is a gap between learning the concepts and theorems in the lectures and solving the homework problems. Another student wrote: "*Sometimes hard to understand concepts first time around, but after homework and review I began to understand*." This message indicated that working on the homework problems was very helpful for students to

understand the concepts, so it is worthwhile to spend some class time helping students on problem solving. Many MOOCs are taught by famous professors, but the completion rates are very low. These online courses are very good in teaching the concepts and theory, but they are not able to help students in solving problems. If our face-to-face courses are primarily lectures, we are not much different than MOOCs except the interaction with the students during the lectures.

Discussion

This pilot hole approach can be applied when the classroom has enough space for students to move about and form small groups. In addition, it is better to have some space between different groups so that the interference can be reduced. Furthermore, the instructor should be able to access each group easily in order to answer their questions. If the classroom is very crowded and the chairs are fixed, this approach is more difficult to implement.

If more than one group has the same question about a problem or there are some points not well explained, the instructor can switch back to the lecture mode and explain the common issues. Actually, this is a very effective way for instructors to get feedback from students. For large engineering colleges, usually the homework is graded by teaching assistants, so the instructors are not able to get much feedback on the issues that students face when they solve the homework problems.

During these practice sessions, students have the tendency to completely solve a problem and then move to the next one, usually they do not have time to start on the last problem. Therefore, the instructors need to admonish the students that they should stop after the method of solution is figured out and then move on to the next problem. It is very helpful if a format sheet is provided to the students, which can help them concentrate on the solution method at a higher level.

Usually each group has strong and weak students, so it is a good opportunity for the students to learn from each other. Sometimes students are more effective teachers than faculty, since they have better understanding of the challenges their peers have. On the other hand, the instructors often emphasize the important concepts and theorems, but ignore the minor details, which often cause more trouble for students in problem solving.

Conclusion

Students relying too heavily on the solution manuals is a serious problem in engineering education, which has detrimental effects to the students' learning. In order to help students in cultivating a good learning habit, we developed a pilot hole approach for a course on Circuit Analysis. With a quarter of class time reserved for practice sessions, students can learn from each other through discussion, and collaborate to find the methods for problem solving. The survey results and feedback messages from course evaluation indicated that most students feel this approach was beneficial, and it also prevented a significant fraction of the students from excessive dependence on solution manuals.

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