Thinking and Understanding from Writing

Prof. Yumin Zhang, Southeast Missouri State University

Yumin Zhang is an associate professor in the Department of Physics and Engineering Physics, Southeast Missouri State University. His academic career started in China; in 1989 he obtained master's degree on Physics from Zhejiang University and then was employed as technical staff in the Institute of Semiconductors, Chinese Academy of Sciences. After receiving PhD degree on Electrical Engineering from University of Minnesota in 2000, he started to work as a faculty member in University of Wisconsin-Platteville and then in Oklahoma State University-Stillwater. His research fields include semiconductor devices and electronic circuits. Since joining Southeast Missouri State University in 2007, he also investigated in the field of Engineering Education.

Dr. David K. Probst P.E., Southeast Missouri State University

David Probst is Professor and Chair of the Physics and Engineering Physics Department at Southeast Missouri State University. Prior to joining Southeast, he was with McDonnell Douglas Corporation (now the Boeing Company) in St. Louis, MO.

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Yumin Zhang, David K. Probst

Department of Physics and Engineering Physics
Southeast Missouri State University
Cape Girardeau, MO 63701

Abstract

Many concepts in physics and engineering courses cannot be understood easily. Although powerful computers with advanced software can generate fancy animations, students still cannot grasp these concepts without spending time reflecting on them. In the past, homework was the tool used by instructors to challenge students and enforce their learning. Unfortunately, now many students can bypass this challenge and directly go to the solution manual for answers, which is widely available from the internet.

One way to nudge students reflecting on the concepts and theories is writing a weekly summary. Unlike the homework, the summary cannot be copied from other sources easily. We asked students to submit their summary through *Turnitin*, an effective plagiarism check software. When they submit their summaries, they can see by themselves how much percent is plagiarized, which will deter them from the practice of copy and paste.

The effectiveness of this approach was assessed in two different ways. The first assessment was a direct questionnaire, and most students considered it very helpful for them to understand the concepts and theories in writing the summaries. The second assessment was a concept inventory test, which was part of the final exam. The test result demonstrated that there was a strong correlation between the scores of the two sections on conceptual questions and problem solving.

Introduction

Engineering Thermodynamics is a very challenging course to many students, since this course requires a new approach in solving problems. Beginning from their first physics course, students are used to solving problems with equations. However, most of the working substances in engineering applications are not ideal gases, and they cannot be described by equations. Instead, students have to rely on the data tables to find the solutions [1]. Furthermore, this course introduces many new concepts, which cannot be well understood without reflecting on them when working on the exercise problems. Unfortunately, since the solution manual is so readily available in recent years, the homework assignments can be completed without much effort in learning and understanding.

There are several different innovative approaches in teaching thermodynamics, and all of them are helpful if the students are fully engaged in their learning. One approach is using simulation programs to analyze various processes [2], which can investigate many practical processes and cycles. Another approach is flipping the classroom, since problem solving is a well-tested approach in learning engineering courses [3]. In this approach, the lectures and worked examples were videotaped and posted online for students to watch, and students use the class time to practice solving problems. As an analogy, listening to lectures is just like the reading process, and solving problems is similar to the writing process, which is much more challenging. Therefore, the practice of flipping the classroom is justified, and instructors can provide help in the latter process. However, the assessment result was often mixed [4]. With emphasis on problem solving, students can do a better job in it only with familiar concepts and theorems. On the other hand, their understanding of new concepts and theorems is often weaker than the conventional way of instruction.

Writing Assignment

In the *Thermodynamics* course offered in fall 2016, we asked students to write a summary every week. This summary has the same weight as the homework; the former emphasizes concepts and theory, and the latter stresses problem solving skills. After the summary was graded, the best one was selected and revised by the instructor, and then it was posted at the class website. In this way, every student could read it and learn something they had missed. Initially the quality of the summaries was not very high, but the posted sample sets up a higher standard, and gradually most students improved their writing on the summary.

There are many plagiarism checking tools available, some of them are free. In our university, the software *turnitin* is a built-in tool in Moodle, an open source learning management system. When students submit their summaries through *turnitin*, it shows the percentage of their essays copied from other sources, and the suspicious sentences and paragraphs are highlighted. In addition, *turnitin* also shows the original sources of these copied sentences to the students and the instructor. Therefore, the approach of copy and paste can be prevented.

When people write something in their own words, they have to think about it in depth [5]. Therefore, this process offers an opportunity for students to reflect on the concepts and theories they learned in the previous week. At the beginning, some students followed the class notes closely and just recorded the knowledge they had learned. Although this served as a review process, the depth of thinking was rather shallow. In the middle of the semester, the format of the summary was revised. Two components were required: the first was “broad review”, and the second was “deep understanding”, which was an in-depth discussion on a specific topic related to the knowledge learned.

In our department the class size is pretty small, so grading the summaries didn’t take too much time. If the class size is large, it could become a heavy burden. Graduate teaching assistants can do a good job in grading homework problems, but they are less qualified in grading the summaries. One option is grading a subset of the summaries, which are selected randomly. The posted sample summaries are helpful in providing feedback to all the students.

Student Survey

At the end of the semester, an anonymous survey was taken and two questions on the summary were asked: (1) writing the weekly summary and (2) reading the posted sample summary. Among the twelve students who took the survey, ten of them (83.3%) considered it helpful or very helpful in writing the summaries. On the other hand, only seven students (58.3%) thought the posted sample summaries were helpful. A comment from one student was: "The sample is a guide to produce our own summary." Therefore, it is not necessary to post the sample summary throughout the semester, it is just needed in the first a few weeks when students are trying to figure out the best way of writing it.

In this survey, students were also asked to rate the challenge level of this course. As a reference, they rated *Engineering Mechanics - Dynamics* at the same time as a reference. The following diagram shows the result:

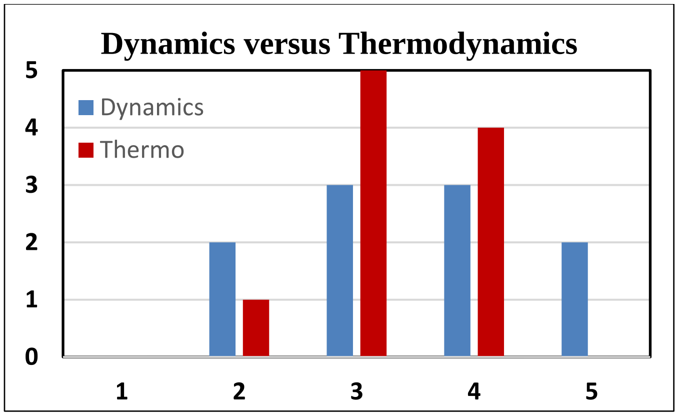


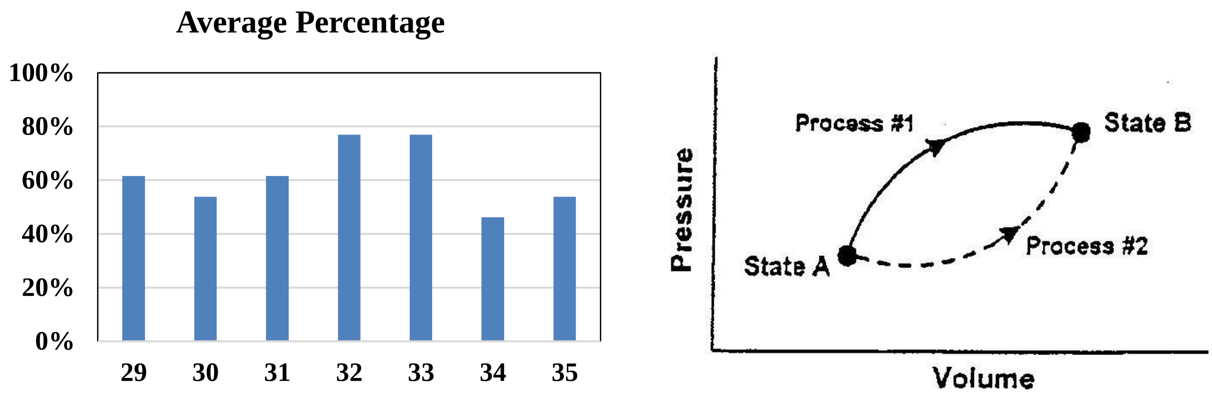
Fig. 1 Survey result on challenge levels.

The horizontal axis refers to the challenge levels: *1* is the least challenging and *5* is the most challenging. The vertical axis indicates the number of students who selected a specific challenge level. Since this course is offered every other year in our department, two students took this course first before taking *Dynamics*, and thus they did not rate that course. The average challenge level for *Thermodynamics* is 3.3, while the number is 3.5 for *Dynamics*. In addition, none of the students selected level *5* for *Thermodynamics*, which indicated that this course was not extremely difficult for them to learn.

Concept Inventory Test

All the midterm exams and quizzes in this courses were on problem solving, in the final exam some conceptual questions were included, which were the questions 29-35 in the *Engineering Thermodynamics Concept Inventory Instrument* [6]. The test results are shown in Fig. 2 (a). The questions #32 and #33 got highest percentage (76.9%) of correct answer, while the question #34 had the lowest percentage (46.2%) of correct answer.

This result is rather interesting, since question #35 is much more difficult than question #34, but its percentage of correct answer is higher (53.8%). We believe that the cause lies at the correlation among the questions #32-34, because all of them are on the same *P-V* diagram shown in Fig. 2 (b). More specifically, they are on work (#32), internal energy (#33), and heat transfer (#34). The details of the test result are the following: five students (32☑, 33☑, 34☑), two students (32☑, 33☒, 34☒), three students (32☒, 33☑, 34☒). These ten students might have applied the first law of thermodynamics in answering question #34. If they made one mistake in either question #32 or question #33, they would select a wrong answer in question #34. On the other hand, the remaining three students did not pay much attention to this law: two students (32☑, 33☑, 34☒), and one student (32☑, 33☒, 34☑).



(a) (b)

Fig. 2 (a) Average percentage of correct answers, (b) *P-V* diagram for question 32-34.

We find that there is a very strong correlation (r = 0.723) between the scores for the two sections of the final exam – the section with conventional problems and the section with conceptual questions, which is shown in Fig. 3. Each number along the horizontal axis is associated with a student, and they are listed in the order of their total scores on the final exam. The numbers along the vertical axis indicate the percentage test scores on the two sections of the final exam. If more conceptual questions were tested, we believe that this correlation could be even stronger. For example, student #4 in Fig. 3 had a perfect score for the section on conventional problem solving, but he made a mistake in question #32, which caused another mistake in question #34. As a result, his correct rate on the conceptual question section dropped to 71.4%.

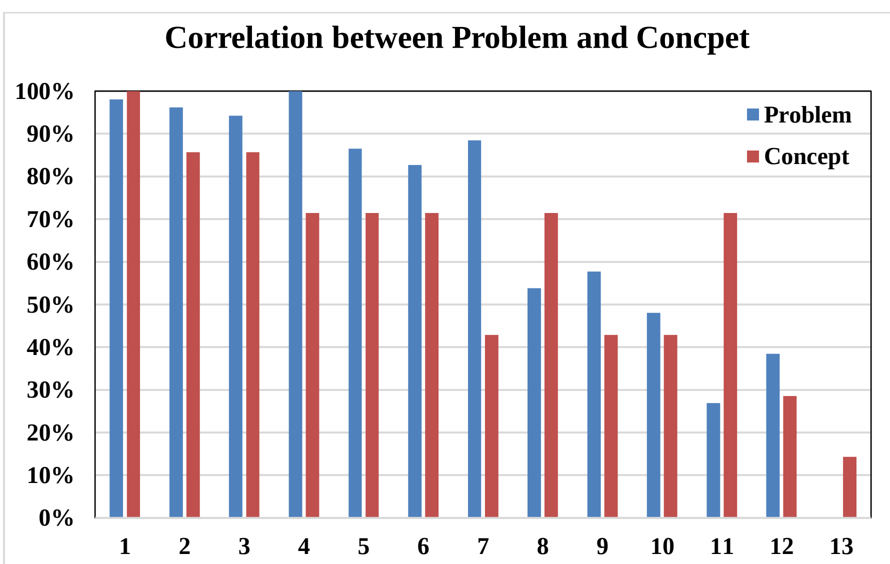


Fig. 3 Correlation between the scores of conventional problem and conceptual question in the final exam.

Summary

Students were asked to write a summary every week, in this way they could sit down and reflect on what they have learned in the previous week. The software used in their submission can check plagiarism, which can prevent the approach of copy and paste. At the end of the semester, most students considered it very helpful in learning this course by writing the weekly summary. In addition, the test results of concept inventory and conventional problem solving shows that the correlation between these two sections was very strong.

Reference

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