
AC 2011-2753: DOES STUDENT ACCESS TO SOLUTION MANUAL POSE A CHALLENGE?

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Does Student Access to Solution Manual Pose a Challenge?

Abstract

Homework problems are assigned to give students the educational experience of solving problems without having access to their solutions and engineering textbooks provide excellent problem sets for homework assignments. Publishers supply solution manuals as a resource for the instructors, with most manuals providing detailed solutions for each problem in the textbook. Since most engineering textbooks solution manuals are currently in digital format, they are readily available to students. This paper provides information on how students get access to solution manuals and gives examples of indicators that students are using solution manuals in completing their homework assignments. It shows the effect of solution manuals on student performance by comparing grade distributions in thermodynamic courses whose students had access to the solution manual with those when most students completed their homework assignments on their own. It is shown that the percentage of unsuccessful attempt in rigorous thermodynamic courses (grades of D, F, and W) increases when students have access to the solution manual. Other contributing factors influencing student lack of success are also highlighted. Alternate methods for assigning homework problems as well as various grading policies used to improve student success are described. The latest method in assigning homework problems as well as a new grading policy has shown significant improvement in student performance and success.

Introduction

Each chapter of most modern engineering textbooks provides several example problems with detailed solutions to help students achieve a better understanding of the basic concepts and theories described in the chapter and demonstrate their use in engineering applications. A large number of problems are assembled at the end of each chapter to be used for homework assignments. One purpose of providing a large set of problems is to give instructors the flexibility of selecting problems for homework assignments that change from semester to semester. Having a large set of problems to pick from, the problems can be varied to reduce the chance that the solutions from previous semesters are available to students.

In addition to a large number of excellent problems in the textbooks, publishers also provide solution manuals as a resource for instructors. These manuals give detailed solutions to each problem in the textbook. Many are prepared in type-set with excellent graphics. In more recent years these solution manuals are supplied in a digital format which makes them easy to be shared via email or downloaded from the Internet. Solution manuals which are intended to be available solely to instructors are now readily available to students, primarily through the Internet.

The purpose of homework assignments is to give students experiences in solving new problems and most instructors would agree that students should not have access to the problem solutions. Homework helps students prepare for engineering employment and practice where they are expected to solve new problems on their own. As students spend time and struggle through solving new problems they develop a deeper understanding of the subject matter.

Students have always been interested in gaining access to the solutions of their homework assignments. Copies of solutions to homework assignments and exam were collected and handed out to students planning to take the same course in the future.

A decade or more before, all solution manuals were in a hard copy format, providing some level of security and reducing the chance of student access. In addition, most solution manuals provided only short solution steps to the textbook problems. In order to make a more detailed solution available to students, the instructors often reworked the assigned problems. Gradually, many authors and publishers began to provide detailed solutions to textbook problems. These are not only good marketing tools, but they are great resources for the instructors, reducing the task of preparing detailed solutions and allowing more time for other course activities and research.

Approximately ten years ago, the publishers began providing solution manuals in digital formats, hence reducing the shipping cost and cluttering faculty office spaces. With the advantages and conveniences of reproducing the solutions and the ease for posting them on-line, the solution manuals in digital format also posed challenges for the faculty as they become readily available to students.

The authors of this paper have been teaching a two-semester course sequence in thermodynamic for many years in the Mechanical Engineering department (ME) at The University of Texas at San Antonio (UTSA). They have realized that the success of students in these courses depends on their motivation, the effort they place in learning the fundamental concepts, and time they spend in solving homework problems. Over time, the authors have developed new approaches in teaching and enhancing student learning¹⁻¹¹. With the changes in technology and student behavior they continue striving to find new ways to reach students and help them learn and succeed.

One area of challenge in recent years has been the availability of solution manuals to students, which in authors' opinion has adversely affected student success. Access to solution manuals allows students to avoid the time and struggle necessary to solve problems and gain a deep understanding of a technical subject. Like sports technical knowledge is gained mainly by practice rather than comprehension. Students who use the solution manual to reduce the time and struggle needed to solve a homework problems, typically develop a shallow understanding of the materials and have little confidence in themselves to solve problems unless the solution manual is checked. In teaching the thermodynamics course sequence, it is observed that those students who have used the solution manual for doing their homework assignments and pass the first course, often have difficulties with the second course and usually receive a lower grade in the second course.

Student Access to Solution Manuals

Within the last decade, we have noticed that each year increasingly a larger number of students were using solution manuals in doing their homework assignments. An Internet search for solution manuals for any engineering textbook produces a list of sources where the solution manuals can be obtained. Examples are Torrentz, e-bay, Amazon.com, or CrAmster.com¹²⁻¹⁵.

All required engineering, math, and science courses in the UTSA's ME program must be completed with a grade of C or better. The authors have observed that the percentage of unsuccessful attempts to pass thermodynamics courses (grades of D, F, and W) increases when students have access to the textbook solution manual. Table 1 shows grade distributions for two courses in Thermodynamics taught by the same instructor. The number of students in each course is identified by N. The table compares grade distribution in a course with low indications that students had access to the textbook solution manual with that where a high percentage of students were using textbook solution manuals to complete their homework assignments. Closed book exams are used in both courses and the same number of exams was given in each course. Table 1 also provides a comparison of average grade point averages (GPA), on a 4.0 grading system, for the two courses. The average GPA might be misleading since the comparison does not exhibit a significant difference in the GPA numbers. However, one should note that grades of W (withdraw) have no influence on the course GPA. The last column in Table 1 shows that a high percent of students had received grades of W without influencing the course GPA. UTSA has a very generous drop date policy, which allows students to drop courses until near the end of the semester. The reason for most students dropping a course and receiving grades of W is because a grade of D or F is expected at the end of semester. Therefore, in reality the class GPA would be lower than 2.04 in the last column, if students stayed in the course until the end of semester. The class GPA would be 1.43 if all grades of W are counted as grades of F.

Table 1. Grade distribution comparison of the same course taught by the same instructor in two separate semesters

Grade	Limited or no Student Access to Solution Manual (N=38)	Large percentage of Students Using Solution Manual for Assignments (N=56)
A	17%	12%
B	31%	14%
C	26%	19%
D	17%	15%
F	9%	10%
W	0%	31%
DWF	26%	56%
Course GPA	2.30	2.04
GPA (W=F)	2.30	1.43

Indicators of Students Access to Solution Manuals

A good indication that students are using solution manuals is when there are errors in the solution manual or in a similar resource, and a group of students submit solutions containing exactly the same errors. Recently we noticed that in the solutions submitted by seven students for a homework assignment, two digits of a 5 digit numbers given in the Steam Tables were transposed. The textbook solution manual contained exactly the same error in its solution for the assigned homework problem. As a second example, approximately 10% of students enrolled in

the second semester course sequence in thermodynamics (Thermodynamic-II) recently submitted a homework assignment containing the same error in the solution of problem which was available on Cramster.com¹⁵. These students' solutions included the same wrong number with 6 significant figures as was presented by Cramster.com. As shown in figure 1, the solution was corrected by Cramster.com, when one of the students pointed out the error. In another example one student asked the instructor in class to explain the solution for one of the homework assignments which included a counter-flow heat exchanger. Water as one stream in the heat exchanger was undergoing the phase change from a compressed liquid state to a super-heated vapor state and the second stream involved the cooling of air from high temperature to a lower temperature. As the instructor was showing the temperature profile of air with a curved line on a graph, one student asked if that line should be straight. When the instructor checked the solution manual later, it was noticed that the air temperature profile was shown as a straight line.

Another clear indication that students have access to the textbook solution manuals are when very few students contact the instructor for help during office hours or very seldom students ask questions regarding homework assignments. In some cases most students get perfect scores on homework assignment and yet they cannot set-up the same or similar problem during the exam.

Also, when the grade distribution plot for a given exam displays a wide spread on student performance, similar to one shown in Fig. 2, one can suspect that many or most of students are using solution manual to solve their homework problems.

Based on the indications described above, in 2004 one of the authors became suspicious that several students in his Thermodynamics-II were using textbook solution manuals to do their homework assignments. After advising students several times that they are not benefitting from using the solution manual and warning them that the University policy considers such usage as plagiarism, the instructor found a web-site address written on a note in his office. The note was slipped under his office door by one of the students in the course. The web-site was hosting solution manuals for 10 mechanical engineering, 10 electrical engineering, and five civil engineering courses. In addition, the website included laboratory reports for a materials course in mechanical engineering. Apparently, the site was hosted and managed by one of the UTSA students. When the word went out that the faculty knew about the web-site, it was quickly taken off the Internet. Since then several different approaches has been attempted to discourage students from using the solution manuals.

Warnings regarding academic dishonesty are included in course syllabi. Every semester, after several warning, a few students have been referred to the Office of Student Judicial affairs, charging them with plagiarism. Even though suspicion existed that there were more students using the solution manual, it was usually more difficult to charge them with plagiarism, since they made sufficient changes to the solutions and numbers presented in the solution manual. Unfortunately, these approaches have not deterred students in using solution manuals; as the number of students referred to the Office of Judicial Affairs has increased every semester.

An instructor main desire is not catching students for using solution manuals and charging them with plagiarism, but is finding ways to help students succeed in their courses.

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Fundamentals of Engineering Thermodynamics 6th

By Moran, Shapiro

Search Results (3): Page 1 of 1



Fundamentals of Engineering Thermodynamics 6th

by Michael J. Moran, Howard N. Shapiro

1733 Homework Solutions

Step 1

Given

Volume of storage tank $V = 2\text{m}^3$

Ambient temperature $T_0 = 17^\circ\text{C}$

Ambient pressure $p_0 = 1\text{ atm}$

Step 6

Substituting values in equation (1)

$$E = (0.362) \left[(491.153 - 206.91) + \left(\frac{8.314}{28.97} \right) (673) \left(\frac{1.01325}{0.35} - \frac{290}{673} \right) \right]$$

$$- (290) \left\{ (2.53064 - 1.66802) - \frac{8.314}{28.97} \ln \left(\frac{0.35}{1.01325} \right) \right\}$$

$$E = 0.362(284.243 + 475.919 - 161.691)$$

$$\boxed{E = 216.646\text{kJ}}$$

Comments (2)

Mistakes (0)



this whole solution is wrong...

1 0

Comment posted by Anonymous on December 14 at 9:40:35 AM



Actually I think they found the incorrect value for the third part. Instead of 161.691 it should be 338.63. The rest is correct and is shown in an example on page 337.

1 0

Comment posted by xTidemanx on December 14 at 11:58:27 AM

Fig.1. Cramster.com¹⁵ solution containing an error used by students for a homework assignment

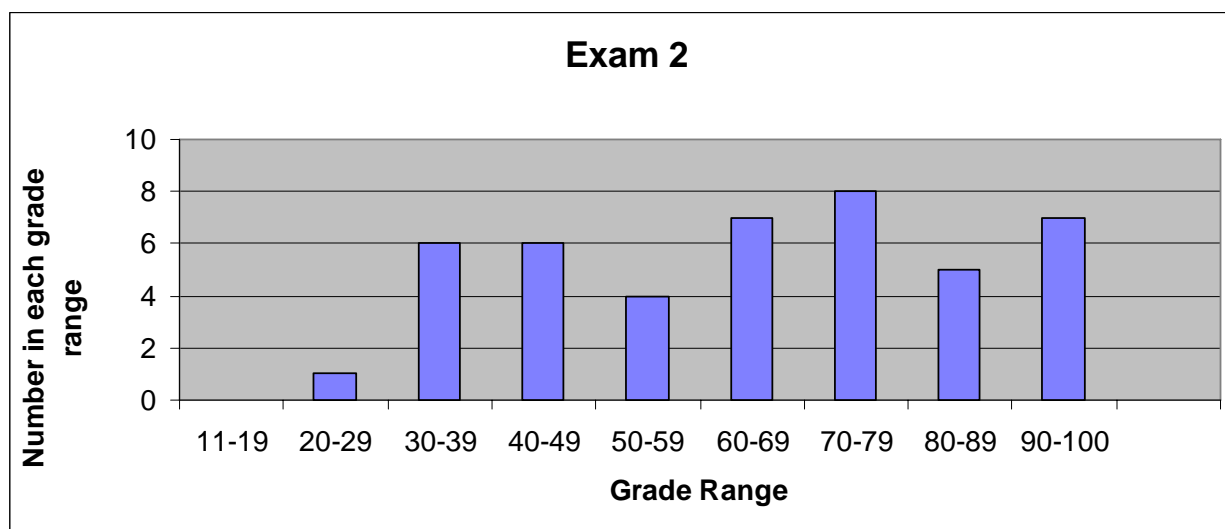


Fig. 2 Grade distribution for the second exam in a recent Thermodynamics-II course (2009)

The passing rates in the first course in the thermodynamics (Thermodynamics-I) have always been low, but they have become even lower in the more recent year. Table 2 displays the grade distribution for the first course in thermodynamics offered during the last five semesters. The figure shows similar grade distributions for each semester, even though the course has been taught by three different instructors. The last column exhibits average grade distribution for the combined five semesters, showing that 55% of students have not been successful in completing the course, as they received grades of D, F, or W. It is believed that one factor contributing to such low passing rates has been the availability of solution manuals.

Table 2. Grade distribution for Thermodynamics-I offered during the last five semesters

Grade	Spring 2009	Fall 2009	Spring 2010	Summer 2010	Fall 2010	Five Semester
A	8%	12%	12%	14%	8%	8%
B	9%	14%	11%	16%	11%	11%
C	28%	14%	18%	19%	30%	30%
D	16%	10%	14%	14%	17%	17%
F	27%	15%	14%	27%	13%	13%
W	13%	35%	32%	11%	21%	21%
Total	100%	100%	100%	100%	100%	100%
GPA	1.50	1.94	1.90	1.73	1.80	1.77
DFW	55%	60%	60%	51%	51%	55%

Addressing the Challenges of Student Access to Solution Manuals

Availability of textbook solution manuals has become a major challenge in recent years for instructors. As demonstrated in the previous section, the availability of solution manuals has adversely affected students' performances; therefore, creating new challenges for the instructors in assessing student homework assignments. These challenges are more pronounced in some courses than the others. In some courses, exams are not sufficient to gauge student knowledge and educational experience. For example, problems involving multistage power and refrigeration cycles in a thermodynamics course are time consuming and cannot be solved completely during a fifty-minute exam period. Therefore, the instructors have to be creative in designing exam problems associated with complex power and refrigeration cycles. Still they must rely on homework assignments in providing a full learning experience for students on topics involving power and refrigeration cycles. The availability of solution manuals robs students from a true learning experience.

In teaching a second course in thermodynamics, the homework assignment used to carry a heavy weight on the final grade for many years. The homework assignments accounted for 30-40% of the final grade as students had to analyze complex thermodynamic cycles involving many components and states. However, starting 10 years ago, it was noticed that more and more students were submitting homework assignments that were either copied directly from the solution manuals or there were good indications that the solution manuals was being used in completing the homework assignments.

It is possible that some students can gain short benefits from using the solution manual effectively by learning the solution steps presented in the manual. However, almost all modern textbooks already provide a good number of example problems with detailed solutions to these problems. Homework assignments are designed to provide additional educational experience for students, by requiring them to set up the solution steps and finding the answers on their own. The aim of homework assignments is to build students' confidence that they can set up the solutions and solving problems without checking the solution manual to see if they have taken a correct approach in solving the assigned problem.

To be fair to students who completed their homework assignment without the use of solution manual, and reducing the pressure for copying from the solution manual, the weight of homework scores on the final grade has been gradually reduced from 20 % to 5%. However, valuing student efforts in completing homework assignments, for several semesters penalties were imposed for not putting any effort into doing homework problems. A policy was adopted that a grade of F would be assigned if the total points earned for homework assignments fell below 30% of possible points, regardless of student performance in the exams. An automatic grade of D was assigned if the points earned for homework assignments fell between 30% and 40% of possible points and if the performance in exams could earn students a grade of D or better. The policy also rewarded students who completed their homework assignments and performed well in exams. For each exam grade above 70 points, homework grades were doubled for the assignments directly related to that particular exam. This policy showed little or no improvement in student performance, or student behavior for using the solution manuals as every

semester more and more students were using solution manuals for their homework assignments. Another policy used to give no weight to the homework assignment unless students earned grades of 70 or higher on their exams. We periodically attempted to assign homework problems from other textbooks. However, it did not take too much time for students to figure out the textbook-source for the homework problems and found solution manual for that textbook.

For one semester (Spring Semester 2010) WileyPlus¹⁶ was used for some of the homework assignment associated with the textbook¹⁷ used in Thermodynamics-I. The WileyPlus is an online resource that allows students to complete their homework assignments online and be graded automatically. The problems are the same as those given in the textbook, except some of the given parameters in the problem statement changes for each student. The WileyPlus system grades the answers as soon as they are submitted online. The system provides several options for the grading process which can be set up by the instructor. The instructor can set up the system such that students can submit their answers only once for credit or accept the correct answer after several attempts for full or partial credit. If students are allowed to provide a correct answer after more than one trial, the instructor can set up the system such that after the first trial with a wrong answer, students are provided with hints and references to appropriate sections of the textbook that can be accessed on line. The flexibility of giving students several chances to find a correct answer was a very useful feature which provided an excellent learning tool for students. The instructor also has an option of hiding the problem number in the textbook, pretending that the problem was not coming from the textbook. We tried this feature, but it didn't take too long for students to figure out that the problems were coming from the textbook. Therefore, for those students who had access to the solution manual, there was no difference in the solution approach, except for plugging new numbers in equations given in the solution manual.

Even though WileyPlus was a good learning tool, it did not reduce the number of students using the solution manual. In fact, the largest number of students were referred (approximately 10%) to the Office of Judicial Affairs for plagiarism. Most of student charged with plagiarism were using solutions supplied by Cramster.com. The number of students referred to the Office of Judicial Affairs, represented only a small percentage of students who were using the solution manual in completing their homework assignment. They included only those who simply copied the solution manual. Others were making sufficient changes to the solution steps which made it more difficult to prove that they were using the solution manual.

Most students who use solution manuals to solve their homework problems do not consider that they are doing anything wrong, and they believe that the solution manual helps them in learning the subject material. In most cases, when the students called in the instructor's office to discuss the use of the textbook solution manual, they claimed that they were using the solution manual only to check the accuracy of their solution, even though they could not show how to begin to solve the same problem that they had received full credit for as a homework assignment. Many argued that they were using the solution manual as a study guide to help them understand the subject better. Since most students are using solution manual in most engineering courses to solve their homework problems, it has become increasing more difficult to convince them that solved example problems in the textbook and the homework assignments contribute to students' educational learning process and being able to solve problems without having access the solution

is an essential part of educational experience. Many students are not very happy, when the instructors advise them not to use the solution manual.

Recent Approach in Assigning and Grading Homework problems

In fall semester 2010 a new approach was adopted for assigning and grading homework problems in the second thermodynamics course sequence. Two different sets of homework problems were assigned for each chapter. One set was assigned from textbook problems which carried no weight on the final grade except for giving students an opportunity to earn bonus points based on their performance in each examination. For each exam grade above 70 points, up to 5 bonus points were awarded based on the number of homework assignment from the textbook attempted and completed. Students were advised at the beginning of the semester that solving textbook homework problems independently is an important part of the learning process and the reason for not awarding any direct points to those problems was to remove any pressure for using the solution manual or similar resources. The second set of homework assignments, called external problems, was developed by the instructor which carried 10 % of the final grade. For this set of homework problems, students were required to start with the most fundamental equations and show all the steps required to modify them for specific applications. This requirement also applied to, some problems in quizzes and exams. For example, for the evaluation of power requirement of a compressor in a refrigeration cycles, students were required to start with the most general forms of equations for the conservation of mass, the first and second laws of thermodynamics and simplify them for a compressor. They had to include all the steps required to show whether the changes in entropy during the process were positive, negative or equal to zero. The following is an example of the problems assigned.

Example Problem

An air-standard Otto cycle has a compression ratio of 5 and temperature, pressure, and volume at the beginning of the compression process are 300 K, 1 bar, and 2500 cm³. The maximum temperature in the cycle is 2000 K.

1. Evaluate the mass of air at the start of compression process.
2. Simplify the general equation for the first law of thermodynamic for each process in the cycle. In each case show the terms that are negligible, by equating them to zero.
3. Simplify the general equation for the second law of thermodynamic for the processes involving the compression and power strokes. In each case show the terms that are negligible, by equating them to zero.
4. Using the results in part 2, derive an expression for the thermal efficiency of the cycle.
5. Modify the equation derived in part 4, assuming constant specific heats.
6. Using the results in part 2, derive an expression for the mean effective pressure of the cycle.
7. Modify the equation derived in part 6, assuming constant specific heats.
8. Assuming constant specific heats at 300 K, evaluate the heat transfer and work for each process in the cycle, the thermal efficiency, and the mean effective pressure.
9. Assuming variable specific heats, evaluate the heat transfer and work for each process in the cycle, the thermal efficiency, and the mean effective pressure.
10. Using the variable specific heat solution in the IT software, plot the net work and thermal efficiency versus the compression ratio (ranging from 5 to 12) and the maximum temperature of the cycle (ranging from 1200 K to 2200 K). Discuss the results. Also compare the results

for the thermal efficiency with that obtained from equation (9.8) of the textbook¹⁷ and discuss the differences.

In addition to the external problems, six pop quizzes, five midterm exams and a comprehensive final exam were given during the semester. Two group design projects and one individual open ended project were also assigned.

Table 3 shows the grade distribution for Thermodynamics-II taught by the same instructor. In spring 2008 and spring 2009 textbook problems were used for all home work assignments. In spring 2008 a limited number of students were using solution manual or similar resources in completing their homework assignments, because a new edition of the textbook was adopted for the course and students did not yet have access to the solutions to all problems in the textbook. In spring 2009 the use of solution manual or similar resources was quite wide spread among most students in the course. In fall 2010, some students were using solution manual for completing textbook homework assignments, but in the new grading policy students received points for the final grades only by solving external problems developed by the instructor. Table 3 shows the highest percentage of grades of DFW in spring 2009 and the lowest percentage of the same grades in fall 2010. It also shows that in fall 2010 the highest percentage of students received grades of A and B as compared to the other two semesters. One reason for student receiving grades of F and W in fall 2010 was because they solved and submitted very few homework assignments and did poorly on the exams. However, in two cases students had very high grades for their textbook homework assignments, but received very low grades on the exams and external problem homework assignments. Both students ended up dropping the course near the end of semester

Table 3. Grade distribution Thermodynamics II taught by the same instructor.

Grade	Spring 2008	Spring 2009	Fall 2010
A	10%	11%	24%
B	20%	18%	29%
C	30%	20%	18%
D	20%	16%	0%
F	7%	5%	3%
W	13%	30%	26%
DFW	40%	51%	29%

Factors Contributing to Unsuccessful Attempts in Courses

In addition to the problem of access to solution manuals, there are several other factors contributing to student failures to successfully complete courses. These include student preparation in prerequisite courses, attending course and doing homework problems. The instructor teaching method might also contribute to this factor. However, we believe instructors can effects the grades positively only if students are willing to put adequate effort in the course.

It is impossible to help those students that never or very seldom attend class, read the textbook, use learning resources provide by instructor on line, or submit any homework problems.

Table 4 shows grade distribution in the Thermodynamics course offered in Fall Semester 2010. The average attendance, average textbook homework scores, and average external homework problem homework grades for each grade category is included in the table. The table shows a direct correlation between class attendance and student effort in completing homework problems. There were two students who had very high scores in textbook homework problems, but had very low grades in the external homework assignments and the exam. They withdrew from the course almost at the end of the semester. They are included among students who received grades of W.

Table4. Correlation between grades, class attendance and student performance in homework assignments, Thermodynamics-II, Fall 2010

Grade	Number	Average Attendance, %	Textbook Homework, %	External Homework, %
A	8	94	47	64
B	10	88	21	46
C	6	88	12	38
D	0	-	-	-
F	1	20	4	0
W	9	49	17	19
Total	34			

Student Survey

Table 5 presents the summary of anonymous course surveys conducted in three different thermodynamic classes regarding the availability and the use of solution manuals in engineering courses. Students were asked whether they agreed with the statements presented in the survey questionnaire. The values presented in Table 5 are the percentage of total responses for all three classes. However, there were some variations between the results for each class. If assigning a value of 5 to an answer identifies as definitely yes, 4 to yes, 3 to maybe, 2 to no, and 1 to definitely no, the last column gives a weighted average for the responses to each statement in Table 5. The numbers in the last column indicate the strength of student agreements with the statements. The number of respondents to each question is represented by the value of N in the table.

Even though it was suspected that a high percentage of students had been using solution manuals in their engineering courses, the numbers were higher than what expected. However, the results are similar to those from two other earlier studies conducted on this subject by others¹⁸⁻¹⁹. The survey results show that 75% of students agreed that copies of solution manuals for most engineering textbooks are readily available to students. Even a higher percentage (92%) agreed that there are resources other than the solution manuals that provide solutions to engineering textbooks problems. Examples are Cramster.com or agencies or individuals who solve homework problems for a fee. For example, in November 2010 an ad appeared on San Antonio

Craig-list²⁰ offering to solve homework problems for several subjects for UTSA students for as low as \$10.

Table 5. Anonymous course surveys conducted in three different thermodynamic classes

	Statement	Definitely Yes (5)	Yes (4)	Maybe (3)	No (2)	Definitely No (1)	Average Value
1	Copies of solution manuals for most engineering textbooks are readily available to students (N =180)	29%	46%	9%	6%	11%	3.76
2	There are resources other than the solution manuals that provide solution to engineering textbooks problems (N =114)	40%	52%	7%	1%	0%	4.32
3	You have used solution manuals in other engineering courses (N =180).	33%	40%	15%	6%	6%	3.88
4	You have used or are planning to use solution manual to do your homework for this class (N =114)	11%	49%	20%	11%	9%	3.42
5	Access to the solution manual helps you learn the material (N =114)	44%	42%	11%	3%	0%	4.28
6	When solution manuals are available, it is difficult to avoid using them (N =114)	18%	21%	42%	15%	4%	3.36
7	Getting a high grade by any means is more important than learning the materials (N =114)	2%	6%	43%	42%	7%	2.54
8	Solved textbook example problems help you understand the material (N =180).	62%	29%	6%	3%	0%	4.50
9	The main purpose of homework assignments is to give you an educational experience to solve problems independently (N =114)	68%	29%	3%	0%	0%	4.65
10	Using solution manuals in completing homework assignments has the same learning benefit as solving problems independently (N =114)	8%	33%	28%	25%	6%	3.11
11	Using solution manual in completing homework assignments provides the same educational experience as solving the examples in the textbook.	20%	37%	24%	15%	5%	3.52
12	Solving homework problems is essential for learning the materials and succeeding in this course (N =114)	80%	15%	5%	0%	0%	4.75
13	You will attempt to solve homework assignments regardless of whether it counts for the final grade or not (N =114)	67%	26%	5%	3%	0%	4.56

Sixty percent of students indicated that have either used or are planning to use the solution manual to do their homework in their thermodynamic courses, even though 97% respondents agreed that the main purpose of homework assignments is to give them an educational experience to solve problems independently. Forty-one percent of respondents believed that using solution manuals in completing homework assignments has the same learning benefit as

solving problems independently, and 95% indicated that solving homework problems is essential for learning the materials and succeeding in the course they were enrolled in.

The result of student survey presented in Table 5 showed that 93% of respondents indicated that they will attempt to solve homework assignments regardless of whether it counts for the final grade or not. However, the homework grades for the second thermodynamics course offered in fall semester 2010, as shown in Table 6 and Fig 3 does not match this claim. Table 6 and Fig. 3 suggest that students put more effort in solving external problems than those assigned from the textbook. Some students did not put any effort in solving textbook problems which did not carry any points for the final grade, except as bonus point. One student who received the highest number of points for the textbook homework assignments received one of the lowest points for the external problems, raising the question whether this student was using the solution manual or similar resources in completing the textbook homework assignments.

The anonymous survey conducted in fall semester 2010 for Thermodynamic-II contained the statements shown in Table 5 plus the ones listed in Table 7. For this course, the responses to most of the common statements were similar to those for the combined courses presented in Table 5, except in two areas. For this course, 45 % of respondents indicated that they have used the textbook solution manual in the course as compared to 60% for the combined courses. Only 9% of respondents believed that using the solution manuals in completing homework assignments had the same learning benefit as solving problems independently, as compared to 41% of respondents in the combined courses.

Table 6. Homework grade range for homework assignments in Thermodynamics-II offered in fall of 2010

	Textbook problems	External problems
Low	1%	21%
High	82%	79%
Average	30%	50%

Table 7 shows that 73% respondent agreed that it was important to solve textbook homework assignments, even though they counted only if they passed the exam; only 23% suggested that the main reason for not solving too many textbook homework problems was because it counted only when they passed each exam; 63% of respondent indicated that the reason for completing more external homework assignments, as compared to text book problems, was because it counted as a part of grade without any conditions; and 50 % of respondents agreed that they completed more external homework assignments because each problem had higher points assigned to it. Eighty-six percent of students thought the external problems were challenging and 95% indicated that completing external homework assignments prepared them for the exams. Also, 82% of respondents agreed that by requiring them to write the most general fundamental equations (1st law, 2nd law, etc.) and simplifying them for specific applications, the external problems gave them a better understanding of thermodynamics.

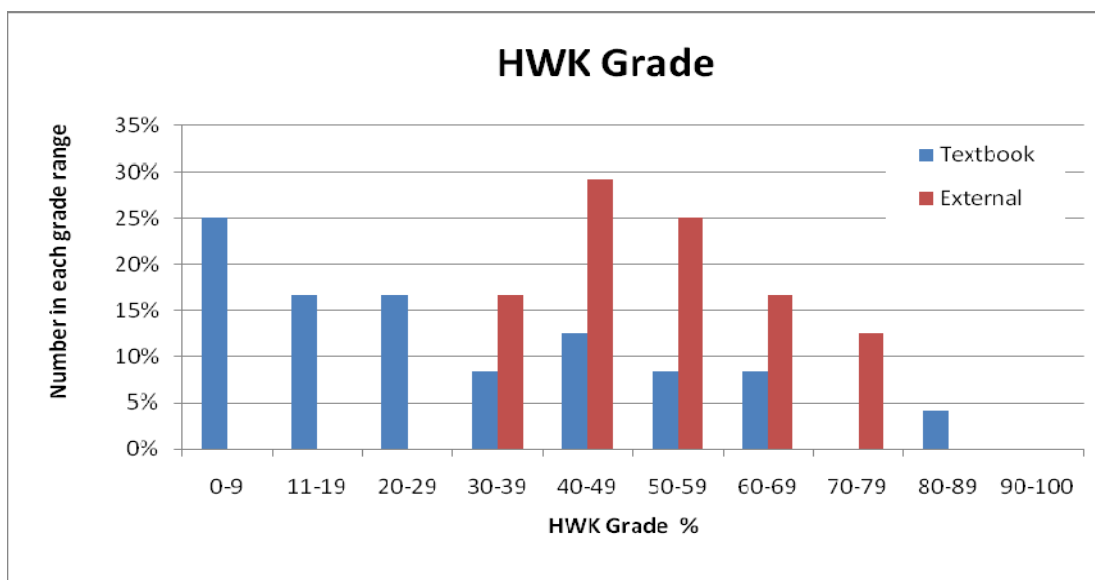


Fig. 3. Comparison of student performance in textbook and external problems assignments, Thermodynamics-II, Fall 2010.

Table 7. Additional questions on the anonymous course surveys conducted for Thermodynamics-II (Fall 2010)

	Question	Definitely Yes	Yes	Maybe	No	Definitely No
1	In this course it was important to do the textbook homework problems, even though it counted only when you passed the exam related to that homework set.	59%	14%	27%	0%	0%
2	The main reason you did not submit too many textbook homework problems was because it counted only when you passed each exam.	5%	18%	9%	32%	36%
3	You completed more external homework assignments because it counted as a part of grade with no conditions.	36%	27%	0%	27%	9%
4	You completed more external homework assignments because each problem had 40 to 100 points assigned to it.	14%	36%	9%	27%	14%
5	The external problems were challenging.	41%	45%	14%	0%	0%
6	Completing external homework assignments prepared you for the exams.	59%	36%	5%	0%	0%
7	By requiring you to write the most general fundamental equations (1 st law, 2 nd law, etc.) and simplifying them for specific applications, the external problems gave you a better understanding of thermodynamics	77%	5%	14%	5%	0%

The course surveys conducted in fall 2010 in the second course in thermodynamics also gave students an option of providing additional comments. The following is a list of comments regarding the use of solution manual for completing homework assignments.

- I think to do well in this class you have to do all your homework or at least attempt to do it. I am not a big fan of using solution manuals in classes because having them tempts you to look at the answer before trying it. When I do have a solution manual for a class though I only use it in places where I get completely stuck. It helps me get a look at how they did. Solution manuals cannot help you on the test. So if you haven't comprehended the material, solution manual or not, you will not pass this course.
- Unfortunately, it seems that there are solution manuals that are available to whoever would like to purchase them for every textbook available. External problems are an excellent idea since there is no solution available to the problems. The only drawback with external problems is that, from what I hear, students pass down old copies of old test and old homework assignments to the upcoming students upon request. If you have the time and energy to create new external problems every semester, this would be the best way to see which students are actually learning the material.
- I am sure you were able to see that some students get 100/100 on textbook homework assignments and a poor score on your external problems. It was also a great idea to not have the textbook homework count as a grade. This will ensure that the assignments are for the students learning benefit only and it would be pointless to copy the solution manual. This semester's method of grading was the best thus far.
- Maybe if you have a student who has 100/100 points on a textbook homework assignment, it would be best for you to call that student to the blackboard to show the rest of us how to solve the problem (because more than likely they have copied the solution).
- Honestly, I think the solution manuals help because it is like having more textbook problems. However, they don't explain step by step so you still have to figure out why they used certain formulas and things like that. Solution manuals really help me because if I spend hours doing something wrong, when it comes down to the test I'm going to remember what I did wrong. That is probably because I spent more time doing the wrong steps over and over again instead of the right steps.
- Using the solution manuals as a reference enables the student to grasp a better understanding of the concepts and method to solve problems he or she would otherwise have trouble conceptualizing and waste countless hours trying to solve to no avail. This is not the same as copying the solutions as homework to turn in, which I don't condone.

It is obvious that not all students were convinced that solving homework assignments without having access to their solution should be an important part of their educational experience.

Students made the following remarks regarding homework assignments:

- To me it doesn't matter if the homework was from the textbook or an external problem, because both prepare you for the exams.
- I am glad that homework assignments did not count for a grade. I did them often but sometimes there just wasn't enough time to do all the homework assignments for all of my classes, and it was a relief to know that I did not have to worry about thermodynamics

homework. I also liked this because it meant less people would cheat and you would have more time to grade the homework submitted by people who didn't just copy the solutions.

- The main reason I didn't do more is because of the amount of time home work took away from assignments in other classes, study time, and personal time. It is doubtful whether I would have done more if the home works were more heavily graded. Most likely it would have just hurt my grade more.
- Too much homework.

The following are student comments regarding the requirement of starting with the most general form of fundamental equations and simplifying them for specific applications:

- Writing the first law and second law really helped me learn the material. I got a C in thermodynamics I and being getting decent grades probably due to the fact of writing the first law and second law every time. Make sure you emphasize this still.
- I am glad that you require us to write the general fundamental equations and then simplify based on the specific problem. Other students who have taken thermodynamics were not required to do this and they have a much harder time working problems than we do. They were taught that specific equations apply to specific examples, whereas we were taught to start with the most basic, and then eliminate variables that we didn't need. I know a lot of students complained about this but it really was for our own good.
- I do feel that writing out the 1st and 2nd laws was helpful but it was also a big part of what made test taking such a lengthy process.

Summary

It is obvious that not all students were convinced that solving homework assignments without having access to their solution should be an important part of their educational experience.

Students made the following remarks regarding homework assignments:

- To me it doesn't matter if the homework was from the textbook or an external problem, because both prepare you for the exams.
- I am glad that homework assignments did not count for a grade. I did them often but sometimes there just wasn't enough time to do all the homework assignments for all of my classes, and it was a relief to know that I did not have to worry about thermodynamics homework. I also liked this because it meant less people would cheat and you would have more time to grade the homework submitted by people who didn't just copy the solutions.
- The main reason I didn't do more is because of the amount of time home work took away from assignments in other classes, study time, and personal time. It is doubtful whether I would have done more if the home works were more heavily graded. Most likely it would have just hurt my grade more.
- Too much homework.

The following are student comments regarding the requirement of starting with the most general form of fundamental equations and simplifying them for specific applications:

- Writing the first law and second law really helped me learn the material. I got a C in thermodynamics I and being getting decent grades probably due to the fact of writing the first law and second law every time. Make sure you emphasize this still.

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- I do feel that writing out the 1st and 2nd laws was helpful but it was also a big part of what made test taking such a lengthy process.

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