



Teaching Strategies When Students Have Access to Solution Manuals

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Abstract

Eight years ago, the lead author undertook a study of instructors who reused homework and exam questions from one year to the next. The results showed that those who reused questions more frequently than once every two years observed more cheating by students who had copies of the previous questions and answers. But since then, the Web has changed everything. Now, Cramster serves up answers to problems from textbooks, and sites like Course Hero encourage students to upload exams for any course. This has endangered all reuse of questions.

This paper reports on a survey of about 140 mostly engineering instructors on the approaches they have taken to adapt to this new challenge. Some have changed the weighting of homework; others have made up their own questions or developed alternate approaches to finding questions. Some have created “stings” for students who illicitly submit answers from solution manuals. It is clear that a variety of responses are possible; we discuss the advantages and disadvantages of the various approaches.

Keywords: examinations, authentic assessment, Cramster, grade calculation, academic integrity

1. Introduction

Ever since the 1840s, textbooks have included exercises designed to deepen student understanding of the material being taught.¹ Early in the 21st century, however, this role of textbooks has become endangered, as solutions to practically any textbook exercise have become widely available on the Web.

Textbook exercises have many strengths. They are typically developed by the textbook author, who is an expert in the field. Authors frequently include questions that have worked for them in their own classes. When other instructors assign these exercises, it saves them the time it would take to create such exercises from scratch. Before the Web, textbook problems also circumvented the need to make paper copies of homework assignments to distribute to the students.

Some textbooks include solutions for selected exercises in the appendix, allowing students to check their work. Others have a companion solutions manual that is intended to be used only by the course instructor. Students often need to be trusted not to abuse these resources. In this networked age, it has become trivial to find the answers to the exact questions online. Online booksellers and file-sharing services make it much easier for students to get their hands on solution manuals, and web forums like Cramster enable students to share exercises and answers from any textbook.

While some textbook publishers have created online systems to mitigate cheating by delivering different parametrized problems to each student,² new instructors are faced with the challenge of how to respond to this issue in their own classes. The purpose of this study was to explore how

instructors perceive and have responded to the student access to solutions for textbook exercises in order to suggest specific approaches to deal with it.

The rest of this paper is structured as follows: we begin with a short discussion of the related literature on student access to exercise solutions. We then present the results of survey sent to three education-related listservs. We discuss the results and conclude with recommendations for new instructors, and avenues for future research.

Related Work

Previous research³ has explored the question of how students and instructors in engineering perceive access to solution manuals. While most instructors consider their use to be a violation of academic integrity, students do not necessarily consider it cheating simply to consult a solution manual. In that 2012 study, nine out of ten Cal Poly students admitted to using textbook solution manuals as a homework and study aid. This shows that students do take advantage of their access to solution manuals.

While some students insist that they only use solution manuals for studying, a study by Widmann, et al.⁴ suggests that there is a harmful effect on student performance when there is easy access to solution manuals. It's obvious that homework grades would be higher when solutions are available, but the study also discovered that performance on final assessments was improved when students do *not* have easy access to solutions, validating concerns about access to these manuals.

Besides using solution manuals, students also frequent online forums to post problems and get help on problems. While some students use these resources for genuine help with learning material, others blatantly copy questions from their textbook and post them on the website. If another user responds to the post in the hopes of accruing reputation points on the forum, not only does this enable the poster to cheat, but it also allows others to find the verbatim solution to the exercise using a search engine. Van de Sande⁵ looked at how these forums were used. She discovered that the culture of different forums affects the kind of help that students get, but in any case, these resources are available to students who find it easier to search for the solutions online than to generate them on their own.

Textbook publishers have adopted measures to mitigate cheating.² Some offer subscriptions to test banks, where new exercises are generated periodically and delivered directly to instructors. This allows instructors to assign them before they are leaked to the web, but this is not ideal, as it still turns textbook exercises into an arms race. Some instructors are dropping the weight of homework in their courses so that there is not a grade-related incentive to cheat, but this encourages cramming for high-stakes exams, which also is not conducive toward learning. Others have substituted alternative kinds of homework, such as large projects and portfolios, but these are typically more time-consuming and difficult to evaluate.

The Survey

In order to find out how others were using textbook exercises, we developed a web survey using Google Forms and sent it to three listservs for college educators and educational researchers: the POD Mailing List, the ACM SIGCSE Members List, and the Engineering Technology* listserv. Most of the questions on the survey were open-ended.

The survey collected 142 responses. Due to the uncontrolled nature of a web survey, this is obviously not a representative sample, as it would be expected that only those interested in the topic of textbook questions would view the message and fill out the survey. However, the purpose of this study is not to identify trends but highlight specific examples of instructor responses.

Figures 1-3 show that these instructors do not rely entirely on textbook questions and are gradually decreasing their reliance on them.

How much of your assigned homework is usually made up of textbook questions?

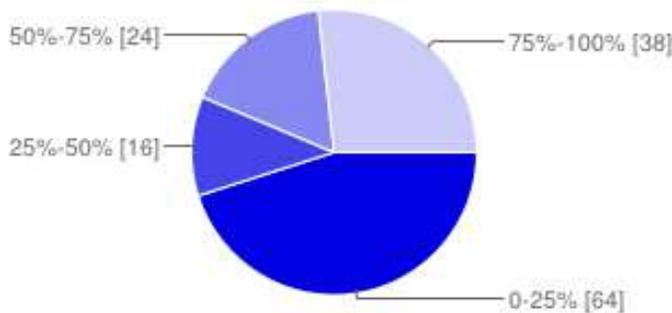


Figure 1. Amount of Homework Made up of Textbook Questions

Alternatives to Textbook Questions

Adjust the weighting of homework

There are many ways to decrease one's reliance on textbook problems. One of the simplest is just to decrease the weight assigned to homework. Exams could be weighted more heavily, with homework serving simply as preparation for exams. Unfortunately, students allocate their time to the tasks accorded most weight. They spend less time working homework problems between exams, and more time studying for exams. This leads to cramming, which has been shown⁶ to be

* pod@listserv.nd.edu, the listserv of the Professional and Organizational Development (POD) Network in Higher Education; sigcse-members@acm.org, the listserv of the ACM's Special Interest Group on Computer Science Education; and etd-l@listproc.tamu.edu, the listserv of ASEE's Engineering Technology Division.

less effective for long-term retention of what has been learned. Studies also show that it is unwise to reduce the weight of homework too far.⁷ Students allocate their time rationally, based on the reward structure they are given. As one instructor put it, “One cannot reduce the weight of homework too much; else the student simply won't do it. When they don't do it, they fail in testing and end up dropping ...”

Another reason to doubt the efficacy of barely counting homework is that it emulates the practice in developing countries. International students report⁸ that homework counts for less in India and China—perhaps 2% to 10% of the grade. One of the motivations is to discourage cheating, but it is also a consequence of the fact that these countries have large numbers of students, a shortage of trained teachers, and almost no TAs. Exams in India are often made up at a well known institution, administered at a less prestigious school, and then graded at the name institution. This serves as a quality-control mechanism, but it places a premium on minimizing the amount of grading. The greater resources devoted to instruction at American universities presumably make it possible to carefully grade homework as well as exams.

Finally, exams cannot measure the totality of learning. It is important that students be assessed on authentic tasks that require them to use the knowledge they have gained to construct work product.⁹ As most research faculty can attest, one does not hire a research assistant by choosing the student with the highest exam score; it's much more important to examine the projects the applicants have completed. If courses become heavily weighted toward exams, assessment is tilted toward the kind of assessment that is not a good predictor of how students will perform on the job.

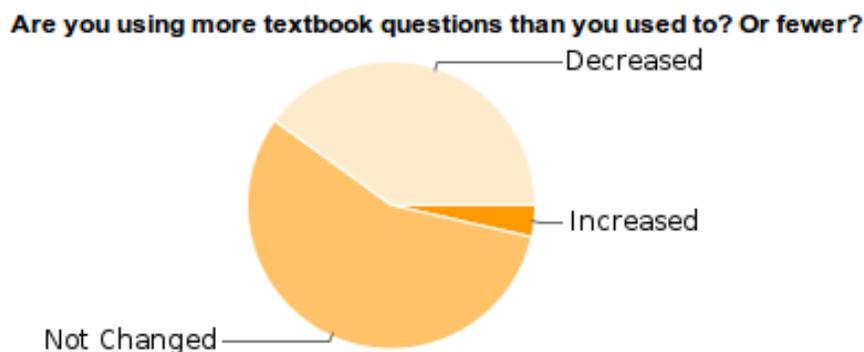
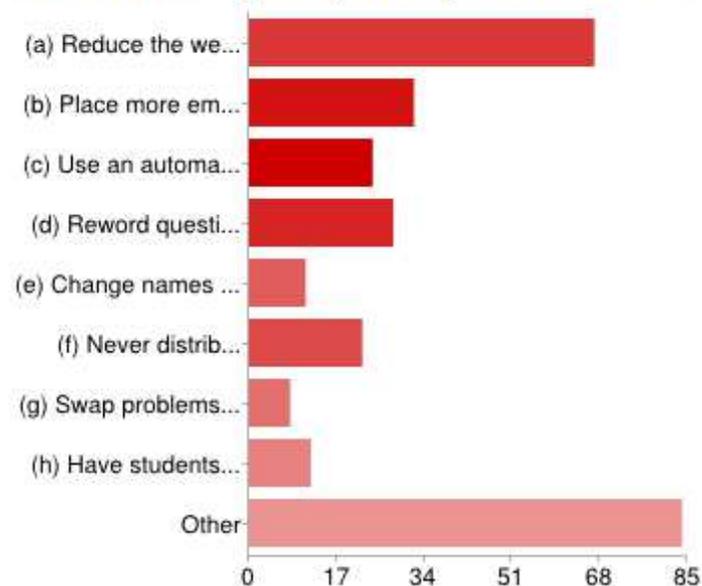


Figure 2. Change in Amount of Homework from Textbook Questions
Most instructors have not changed their use of textbook questions, but of those who have changed, almost all have decreased usage.

Which of the following strategies have you used to deal with the fact that students have access to answers?



- (a) Reduce the weight of homework so that more of the grade depends on exams.
 - (b) Place more emphasis on having students design artifacts and less emphasis on having them solve problems.
 - (c) Use an automated testing system that can randomize parameters, so each student is presented with a different problem.
 - (d) Reword questions so that a text search will not find them.
 - (e) Change names of people or organizations named in word problems.
 - (f) Never distribute answers in the same document with questions, and refrain from putting the semester or year on question or answer sheets; this makes it much harder to match questions with answers.
 - (g) Swap problems with other instructors (e.g., at other institutions).
 - (h) Have students make up problems that can be assigned to later classes.
- Other

Figure 3. Strategies used to cope with student access to answers

If one desires to decrease the weight of homework, a better alternative is give a quiz over the homework at or before the beginning of the next class, and count it as part of the student’s grade. Quizzes can be administered—autograded—by Web-based software, but there is some advantage in giving them during class time, since this provides an incentive for students to come to class.

Another good alternative is to place more weight on *authentic* projects, such as programming or design projects. “Authentic” work is a task that students may be asked to perform later on the job. In both programming and design projects, students are *expected* to come up with different answers; when they don’t, that is cause to suspect cheating. In the case of programming, there are tools like MOSS¹⁰ that can detect when one submission is the same as—or a mechanical

transformation of—another student’s submission. It’s possible to give homework *and* exam questions where no two answers are identical. One instructor explained,

Some time ago I adopted a strategy where I give assignments and exam questions where the answer is expected to be unique for each student. For example "explain ... In your own words" or "give an example not found in the class notes or textbook" or "construct a diagram of ..." These are harder to grade but students consistently tell me they learn more in my classes than in any others.

Use questions from other sources

A few textbook publishers come out with new problems in between editions of a textbook. One of our respondents noted that the publisher of a textbook (s)he uses came out with a “Fourth Edition, revised,” which was the same as the “Fourth Edition,” except that the problems were different. “Students mistakenly purchase the wrong version and create a problem for themselves,” the instructor commented. Several others noted, however, that new problems would be of limited value. One remarked, “ If the solutions are provided to the instructors electronically, then they will end up on the Internet before I have them, anyway.” Another instructor said he had already observed this:

“I teach upper level engineering courses such as Structural Analysis, Steel Design and Concrete design. The publisher of the text has a ‘secure’ answer site so I tried to use the text’s problems. I used to give open book and open notes tests. The students have hacked into the site and given me back the author’s answers even when they were incorrect. They made it impossible to use these problems anymore.”

Instructors can, of course, make up their own homework problems. Though this was not an option suggested in the survey, 19 instructors volunteered that they did this. Most of these prefer their own problems to textbook problems; 14 of them said that less than 25% of the problems they assigned were from the textbook.

But, there are costs to devising one’s own homework problems. It takes time away from other activities, such as course development, meeting with students, and devising better explanations and examples for class. Since the time spent writing well thought-out problems is proportional to the time required to solve them, it creates a bias toward easier homework assignments, which may be less effective in promoting learning. For complex problems, including programming assignments, it’s difficult to “get it right” the first time, with the result that confused students waste time on half-baked problems, hurting their learning and their impression of the course.

Finally, if different cohorts of students are constantly assessed with completely different homework and exam questions, it is nearly impossible to compare student performance between semesters. This increases the difficulty of deciding whether teaching interventions are

succeeding in improving student learning. This ultimately makes it more difficult for instructors to improve other aspects of their teaching.

Making up one's own problems takes less time if one can trade problems with a colleague at another institution. This does not seem to be a common practice; only 3% of our survey respondents indicated that they did this. An instructor must locate someone who uses the same textbook with a similar student population. Organized efforts to collect problems from instructors haven't fared much better. Projects such as the National Science Digital Library and MERLOT collect digital resources to be shared among educators. Few if any of these resources are exercises that one can assign for homework. A decade ago, one of the authors led a project to collect problems in computer architecture.¹¹ It attracted 130 users, but fewer than 10 contributors.

It's also possible to take problems from textbooks other than the text for the course. One respondent wrote, "One strategy that seems to work for me. Select two texts for a course. One is the public text, the other is one I select problems from. Yes, this involves a lot of retyping/rewording on my part, but so far it has eluded rampant cheating." Of course, an instructor can borrow problems from several textbooks, though textbooks vary tremendously in their treatment and order of coverage, which tends to limit the number of problems that are usable for a particular course.

Another strategy is to assign students to make up problems for homework, then choose the best of these to assign to subsequent classes. Making up a problem is a good metacognitive exercise, since it makes students think about how to apply important concepts. One of the authors used this practice for years, having students peer-review each other's questions.¹¹ By the end of the period, one-fourth to one-third of his homework and test questions were comprised of problems made up by students. Most of these problems required some rewording, most commonly to take hidden assumptions from the solution and make them part of the problem description. Systems like PeerWise exist for students to develop such questions and submit them to a repository that can be used later by educators.¹²

Alternative means of assessment

We have mentioned peer review as a way of vetting student-authored problems, but it is also useful for assessing any kind of open-ended work. This includes writing exercises,¹³ design problems, and program code.¹⁴ Available peer-review tools include Calibrated Peer Review, Peer Scholar, Sword, and the author's Expertiza¹⁵ system. If assignments are done in teams, one can gauge the contributions of various members by having the students assess each team member's contribution to the project. The CATME application¹⁶ is useful for this.

New pedagogies

In the last twenty years, a variety of techniques have been developed for helping students to work in groups. Their purpose is to promote active learning, but they also serve to discourage

copying answers, because students arrive at the correct answer through discussion, and these discussions are overseen by facilitators.

Problem-based learning (PBL)¹⁷ has students working cooperatively in groups of 8 to 10, overseen by a facilitator. Students begin with a description of the problem, and then learn, on a need-to-know basis, what is required to solve the problem. Team-Based Learning (TBL)¹⁸ has students work in a group of 6 or 7, chosen by the instructor so that each group contains students with complementary skills. Students engage in individual activities outside of class (such as studying material and taking quizzes) to ready themselves for group work during class. From time to time, the instructor calls on students to share their answers with the entire class. Other groups compare their answers, and the instructor can guide the discussion.

In Process-Oriented Guided-Inquiry Learning (POGIL), students work in teams of 3 to 5 for an entire class period on a single activity, taking it through three stages: exploration, invention, and application. If the activity is not finished during the class period, students finish it for homework. Peer-Led Team Learning (PLTL) has the students meet in small groups outside of class to work on concepts introduced in the textbook or lecture. The groups are led by students, usually students who have taken the course in the previous semester or year.

Obviously, the decision to employ any of these pedagogies for the first time will require major changes to a class. Research indicates that it will be valuable, in reducing dropout rates both from courses and curricula. The fact that it reduces or eliminates Web-based cheating is simply a side benefit.

Catching cheaters and loafers

Instructors have used several strategies to catch students who, in contravention of rules, use solution manuals or other Internet sources to “do” their homework. Students might be required not only to give the correct answer, but also to explain it in their own words. Students might even be given the answer, but required to explain it::

“When I assign homework - a student learning exercise - I give the “Bottom Line Answer” (BLA) to every assigned problem. The BLA is often given in texts. I require a full solution - problem statement, governing equations, variable substitutions, and detailed solution - on which I comment and score the assignment. If I don't see frequent erasures and rewrites, I suspect plagiarism and I warn the student.”

To prevent students from using other Internet sources, one instructor made a rule that answers to homework exercises must use only concepts covered in the class:

“I tell students they can use the Internet to solve problems — but their solutions, no matter the source, can use only things we have covered in the course or that are in our textbook. Using other things results in 0 credit on the problem.”

A caveat is that students might actually have learned a technique from an Internet source, and not remember that it wasn't covered in class; if it applies to the exercise in question, it seems arbitrary to forbid them to use it.

An instructor who makes up questions and wants to reuse them can take measures to keep the answers from getting out:

I've stopped allowing my students to take exams home with them. After reviewing exams in class, I re-collect them. A student's old exams can be a useful study tool for that student, but it's become too easy to share exams on the web.

Instructors can use a variety of “sting” operations to catch students. One instructor explained, “There are some incorrect answers in some answer manuals. I assign these problems purposely in order to catch the cheaters.” Another technique is to leave the wording of the problem the same, but change parameters in order to catch students copying answers: “I **do** have problems w/ students trying to copy answers from previous year's [sic] exams, and copying them incorrectly because the questions/numbers/unknown has been changed when I make the new exam.” Another instructor shared this anecdote:

“I also vary things from year to year, and not only are copies easy to detect but sometimes they are hilarious. For example, I once had an assignment on a take-home exam where they were supposed to assess the risk of using Cobol for a high performance, real-time application. In a later year I reused the question but changed the language to Java and had a student write that “Java is inappropriate because it is intended for use with business data processing applications (and on and on extolling features and limitations of Cobol!).” A quick search led to a paper written ten years earlier by another student who had the identical answer except that it was about Cobol.”

Conclusion

As computers and the Internet become more connected and ubiquitous, student access to textbook exercise solutions continues to grow, reducing their utility in a classroom setting. The responses of this survey indicate that instructors recognize this as an issue, and are reacting in a variety of ways (Table 1). While this has increased the challenges in assessing student learning and performance, instructors do not necessarily view student access to solutions as detrimental to learning in and of itself. As one instructor noted ...

“... Overall, availability of information over the Web has markedly increased student learning, by allowing them to easily augment course content with additional material.

Availability of homework solutions over the Web impacts the assessment of student learning. More precisely, it impacts the effort that instructors need to make in order to effectively assess student learning.”

Table 1. Summary of Alternatives to Address Use of Solution Manuals

Adjust the weighting of homework

- Reduce weight of homework; increase weight of exams.
- Reduce weight of homework; give quizzes over homework that count in the grade.
- Reduce weight of textbook questions; increase weight of projects.

Use questions from other sources

- Use new exercises provided by textbook publisher between release of new editions.
- Make up your own homework exercises.
- Swap original homework exercises with instructors at other schools.
- Use exercises from textbooks that are *not* the text for the course.
- Assign students to make up exercises; choose the best to assign as homework in later semesters.

Obscure the source of the exercise and/or the solution

- Don't tell students that the problems are from the/a textbook.
- Reword questions so a text search will not find them.
- Change the names of people or organizations in word problems.
- Never distribute solutions in the same document with exercises; refrain from putting semester or year on question or answer sheets

Use alternative assessment

- Peer review by other students in the course
- Review by teammates

Use new pedagogies

- Problem-Based Learning
- Team-Based Learning
- Process-Oriented Guided-Inquiry Learning
- Peer-Led Team Learning

Employ strategies for catching cheaters and loafers

- Require students to explain the answer in their own words.
- Collect worksheets on which students have derived the correct answers.
- Prevent students from taking solutions or graded work outside the classroom.
- “Sting” operations
 - Purposely use questions for which the solution manual has the wrong answer.
 - Leave the wording the same, but change one parameter of a textbook exercise, and see how many students turn in the answer for the original parameter value.

We have presented a variety of approaches to mitigating the problems posed by student access to solution manuals. Some of them—like increasing the weight of exams—may have detrimental

effect on assessment and learning, but others—like the four new pedagogies (PBL, TBL, POGIL, and PLTL) promise to improve student engagement and learning, as well as render access to solution manuals a non-issue. We provide a variety of suggestions for new instructors, so that they may be able to take control of the challenge rather than be defeated by it.

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