

How to Design Homework Assignments for Students Who Use Search Engines Instead of their Textbooks

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Abstract

In a survey course such as Introduction to Materials, homework assignments are often based on readings from the textbook. However, many students find it easier to use search engines to look up the answers on the internet. Rather than obstruct this natural tendency, instructors can take advantage of it by assigning questions that require intelligent use of internet resources. Solutions lead to class discussions about the meaning of the results. This paper discusses several materials homework assignments requiring internet research. Students learn that some answers are very difficult to find, and that accuracy of data on the internet is not guaranteed. Students also learn how materials data affect design, economics, and public policy.

Key Words

Innovative Teaching Methods

How to Design Homework Assignments for Students Who Use Search Engines Instead of their Textbooks

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Introduction

I teach a second-semester freshman materials class for Mechanical Engineering Technology students at a branch campus of a large Midwestern state university. The course uses the first half of Kalpakjian & Schmid's *Manufacturing Engineering and Technology*ⁱ to cover the basics of materials structure/property relationships, materials testing, and materials processing. About half of the freshmen are traditional-age, and half are returning adults with full-time jobs. I assign weekly homework problems to assess students' understanding of the lecture, labs, and readings from the textbook. While the older students generally find solutions in the textbook, the younger students are more apt to seek answers on the internet because it is quicker. I wanted to encourage this activity, because in my experience as a materials engineer in the automotive industry, I routinely used both the internet and traditional handbooks to solve materials problems. Therefore, I changed the nature of about a third of the homework questions to encourage students to learn from the internet, and in other cases, I designed problems which could only be solved by reading the textbook.

As the semester progressed, I rated the questions based on students' success at finding correct and meaningful answers on the internet. Student success ranged from low to medium to high. We discussed the solutions in class, then discussed the broader meaning of these solutions and their context in engineering and society, using approaches recommended by McKeachie.ⁱⁱ What follows is a selection of internet questions from the course, along with class discussion topics.

Homework Questions which Use the Internet

1. *Rank these states in order of steel production: PA, OH, IL, IN, MI. Give current production figures, and list all sources. (Low Success)*

I assign this problem in the first week of class. Most students assume that everything is easy to find on the internet, but they quickly learn that this is a hard problem. Unless they discover the USGS Minerals Commodity website,ⁱⁱⁱ they are unlikely to find this information easily. They are often surprised to find that Indiana leads the nation, producing four times the tonnage of Pennsylvania.

Some students discover that state governments and industry groups collate the results differently than the USGS. For example: states may be ranked by tons of raw steel produced, tons of finished steel produced, or the value of steel products.

2. *What is the most-recycled metal in the U.S.? (Moderate Success)*

The most common student answers included steel, aluminum, and lead, depending on which industry-sponsored website was cited. In our class discussion, I point out that the problem

statement is too broad. I ask the students to define the term “most recycled”. Is it the total value of recycled material? Is it the total tonnage? Is it the ratio of tons recycled to tons produced in any one year? What about the life cycle of the product? The material recycled today may have been produced many years ago. Do imports and exports count? The answer depends on how the question is asked, so students learn to be more discriminating about reported recycling rates for metals and plastics.

3. *What alloys are used for making bimetallic strips? Why are these alloys used? Cite all references. (High Success)*

Students easily find these alloys on internet encyclopedias. The information is also available in their textbook. As they read further, they learn about differences in thermal expansion coefficients of different alloys. In class, we follow up with a discussion of zero-expansion materials and their applications.

4. *Download an MSDS for an adhesive or sealant material. What precautions would you take if you introduced this material to a production line? Attach a copy of the MSDS, and list the website source. (High Success)*

Many of my students work in factories where industrial chemicals are used. This assignment shows that MSDS forms are available on the web, and it helps students think about chemical safety.

5. *How do industrial recyclers separate different kinds of plastic? Be specific about detection methods, use the internet, and cite all sources. (High Success).*

This topic appeals to MET students because it involves machines and instrumentation. Students do a great job of researching the question.

6. *What are “fiberglass” roof shingles made of? Is this a composite material? If landfilling shingles were prohibited, how would you recycle used shingles? Cite all sources. (Moderate Success)*

Most students are able to discover what these shingles are made of, but the recycling question is harder. In the classroom, we discuss the problems associated with recycling composites of all kinds, including automobile tires, metal matrix composites, paving materials, glued forest products such as particleboard, and reinforced polymers.

7. *Find the linear coefficient of thermal expansion at room temperature and absolute melting point for Cd, Pb, Mg, Al, Cu, Ni, Fe, Ti, Nb, Ta, and W. Plot the coefficient of thermal expansion vs. the melting point. What relationship do you observe? (Moderate Success)*

The melting points are listed in the textbook, but students have to find the linear expansion coefficients from technical handbooks or the internet. Graphs typically look like the left side of Figure 1, where the outlier is magnesium. A few students annotate their graphs with questions about the outlier.

A widely repeated error on the internet is the coefficient of thermal expansion for Mg. Many websites list it at around 8 mm/mm/°C, which is one third of its actual value. Using the correct value for magnesium, the graph should look like the right side of Figure 1.

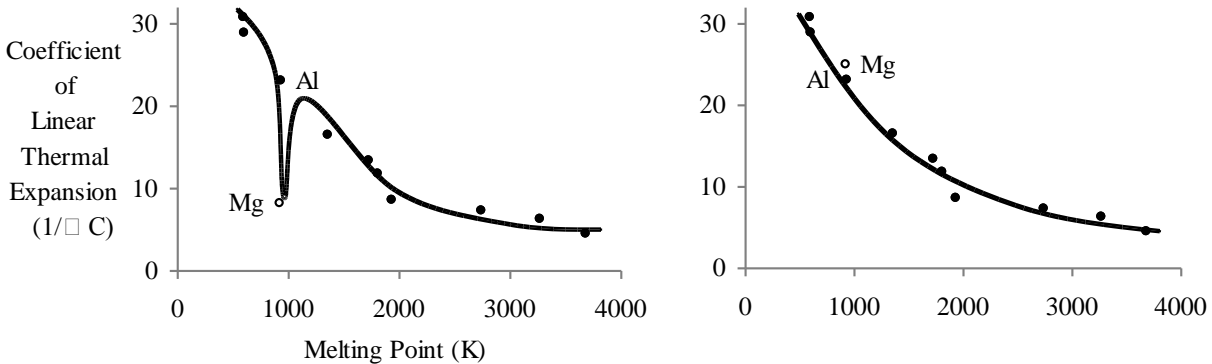


Figure 1: At left, a typical graph for this assignment shows magnesium substantially below the trendline. Many students draw a line passing through the magnesium point. When the correct value of magnesium is used (right), the trendline passes near all points.

In class, we compare the two graphs, and discuss errors on websites. If the assignment had been to generate a table of numbers, this error would not have been as easy to detect. The graphing exercise shows students a method for detecting errors in reported data.

8. *What reinforcing material did Thomas Edison use for his concrete swimming pool in Fort Meyers, Florida? Why did he select this material? Cite all sources. (High Success)*

Some websites describe the use of bamboo as a reinforcing material. This answer leads to a discussion of concrete reinforced with carbon fiber in Japan.

9. *Fort Wayne, Indiana, is known for producing magnet wire. What is magnet wire? How does it differ from other types of wire? Cite all sources. (High Success)*

Virtually all students answer the first part of this problem completely. In class, we follow up with a discussion of other types of wire, including medical wire, which is made locally.

10. *Use the Internet to find the curb weight and city gas mileage of at least ten gasoline-powered, manual-transmission automobiles. Make sure the most efficient vehicles on the list are at least 15 mpg more efficient than the gas guzzlers on the list. Plot the gas mileage vs. curb weight. What do you learn from this plot? (Moderate to High Success)*

Students learn that the curb weight is easier to find on some automakers' websites than others. Most students observe that light cars get better gas mileage than heavy ones. In class, I show the students a graph with nearly 80 vehicles.

City fuel economy is a function of weight, because city driving involves repeated stops and starts. Hybrid vehicles usually have better city fuel economy because they recover and reuse a substantial proportion of the braking energy, which in an ordinary vehicle is lost as heat. (The "mild hybrid" Saturn Vue is an exception to this rule...it is the data point closest to the conventional vehicles.)

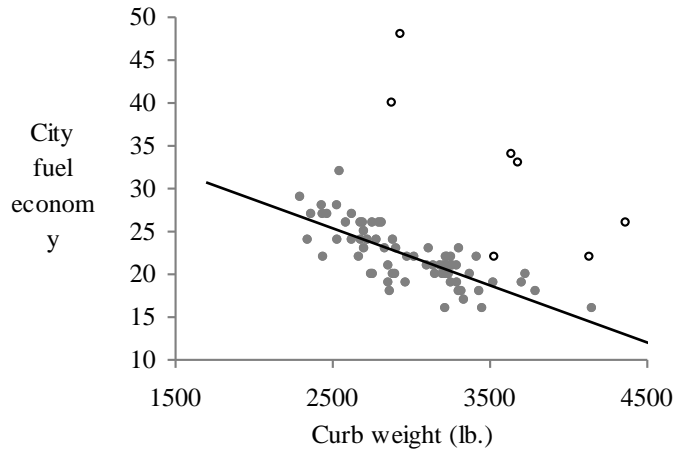


Figure 2: EPA city fuel economy as a function of curb weight for model year 2008 manual transmission vehicles (gray, with linear regression line) and hybrid vehicles (white).

I follow Figure 2 with a graph of the cost of gasoline over time:

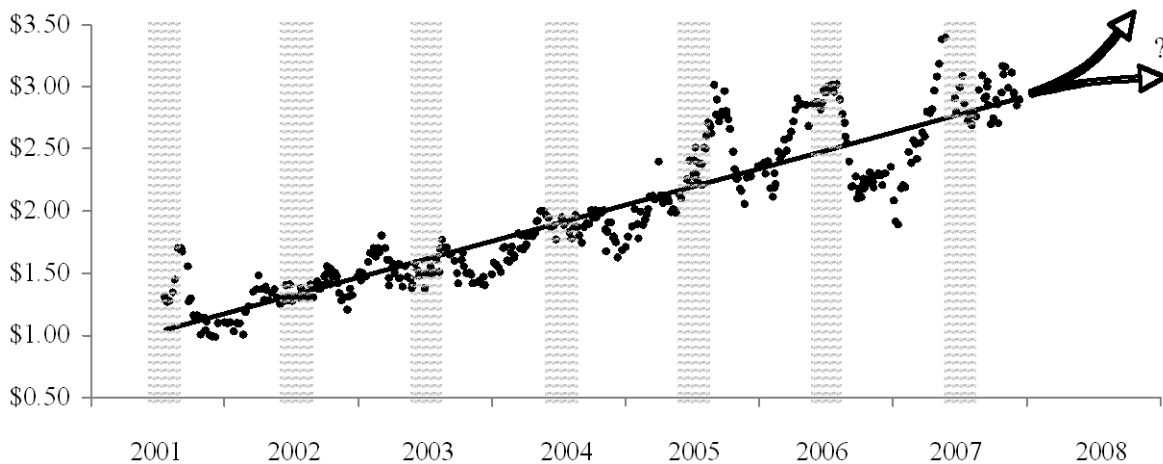


Figure 3: Cost of regular unleaded gasoline (current dollars)^{iv}. Shaded columns are summer months.

Seasonal fluctuations and Hurricane Katrina (2005) have caused spikes and dips. In some years, prices rose during the summer, then dropped in the fall (e.g. 2001, 2003), while other years the prices rose in the spring, then fell in the summer (2004, 2007). The overall price has increased 14% per year since 2001. As fuel costs continue to rise, the marketplace and government regulations will encourage industry to develop new vehicles. This opportunity represents job security for MET graduates, materials engineers, electrical engineers, and graduates of other engineering and engineering technology disciplines.

11. *What is tube hydroforming, and why did Dana Corporation start using it to make truck chassis parts? (Moderate Success)*

Some answers are best found on corporate websites, rather than on internet encyclopedias. Dana uses tube hydroforming to manufacture side rails for the Lincoln Navigator and Ford Expedition. In the classroom, we discuss the economic reasons for using this process.

Homework Questions which Use the Textbook

The course uses a well-written textbook, so many of the assigned homework problems encourage students to read and understand the book. For example:

- Plot the tensile strength of reinforcing fibers in Table X as a function of their density, and explain your observations.
- Explain what the author means by _____.
- The textbook defines “stripper plate”. What is this item used for?

This last problem is a deliberate ploy to get students to read the book carefully. A stripper plate removes the workpiece from an extrusion punch. This term is not in the index, and any student who uses a search engine will quickly be overwhelmed by unrelated sites.

Marton and Säljö^v studied various kinds of homework questions, and found that assignments are more effective if they focus on thinking rather than fact retrieval. A hazard of asking “what”, “how”, and “where” problems is copy-and-paste answers, so occasionally I ask a “why” question. For example: “Why do you think there are separate numbering systems for cast and wrought copper alloys?” One student came to my office hours to ask where he could find the answer on the internet. Only after we read the problem statement together, slowly, emphasizing “*why do you think...*”, did he understand the point of the question.

Assessment

Student success at completing problems correctly was assessed through grading. Student opinions about the internet-based homework assignments were assessed indirectly through two measures. The first measure used the departmental course evaluation survey. Students were asked to rate the statement “Assignments / homeworks are related to the course goals”. Before I started using internet-based questions, the ratings on this question were 8% below the departmental average. In subsequent semesters, the ratings ranged from 0% to 11% above the departmental average. The second measure was an extra-credit question on the final exam: “Discuss at least three ways to improve this course.” Over the course of six semesters and 83 students, only three responses addressed the homework assignments:

- “The homework is too hard.”
- “The homework was hard and no fun, so less homework, more labs.”
- “The homework is good as it is, don’t change it.”

The remarkable lack of feedback on the homework assignments suggests that a more direct measure of student opinions is needed. Currently, I offer students extra credit for specific, actionable feedback on lecture handouts, if they provide the feedback in writing. This approach could easily extend to the design of homework problems.

Conclusions

The internet can be a useful and productive resource in a freshman materials course, provided that the homework questions are carefully designed. In my class, students have learned to use the internet to research materials properties, economic data, manufacturing methods, safety and handling data, and materials selection. Given the variability in student success, in future semesters I will invite a librarian to class to show students how to perform more successful internet searches. I also plan to encourage more interest and engagement by designing problems requiring group effort, as recommended by Light.^{vi}

Materials engineers routinely use the internet as a source of several kinds of information: pricing; materials properties; safety and handling; fractography and failure analysis; microstructures;^{vii} supplier locations; etc. My hope is that carefully designed homework assignments which help students learn these skills will be transferable to the workplace after graduation.

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- iii The U.S. Geological Survey issues annual reports on more than seven dozen nonfuel minerals and metals, available at <http://minerals.usgs.gov/minerals/pubs/mcs/>.
- iv Data from the author's purchases of gasoline, primarily in northeast Indiana.
- v Marton, F., and Säljö, R., "On Qualitative Differences in Learning: II – Outcomes as a Function of the Learner's Conception of the Task". *British Journal of Educational Psychology*, **46**, 1976, p. 115-127.
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- vii The Copper Development Association has some particularly good microstructures of copper alloys at www.copper.org.