AC 2008-35: USING INTERNET SOURCES TO SOLVE MATERIALS HOMEWORK ASSIGNMENTS

Barry Dupen, Indiana University-Purdue University-Fort Wayne

Dr. Dupen worked for 9 years in the automotive industry as a metallurgist, materials engineer, and laboratory manager. For the past 5 years, he has taught Mechanical Engineering Technology at Indiana University Purdue University Fort Wayne (IPFW). His primary interests are in materials engineering, mechanics, contra dancing, and engineering technology education.

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Abstract

Materials professors commonly ask homework questions derived from textbook readings, only to have students find the answers faster using internet resources such as Wikipedia or Google™. While we hope students will actually read their textbooks, we can take advantage of student internet use to teach materials concepts. After graduation, these engineers will use the internet as a resource in their jobs, so it makes sense to use the internet in classroom exercises too. This paper discusses several materials homework assignments requiring internet research, and a few which require the textbook. Students learn that some answers are very difficult to find, and that accuracy is not guaranteed. Students also learn how materials data affect design, economics, and public policy.

Introduction

I teach a second-semester freshman materials class for Mechanical Engineering Technology students, using the first half of Kalpakjian & Schmid’s *Manufacturing Engineering and Technology*¹ (the second half of the book is covered in a subsequent materials course). The course covers the basics of materials structure/property relationships, materials testing, and materials processing. Because I teach at a branch campus of Purdue University, the class is populated by a mixture of full-time traditional-age students who may work part-time jobs, and part-time older students who work full-time jobs. I assign weekly homework problems to assess students’ understanding of the lecture, labs, and readings from the textbook. While students older than 30 generally find solutions in the textbook, their younger classmates 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. When I returned the graded assignments, 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 These discussions satisfies ABET criterion “j” (knowledge of contemporary professional, societal, and global issues), while the internet research satisfies ABET criterion “h” (lifelong learning). 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, 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 the former steel leader, Pennsylvania.

Students who use state government and industry group websites find that these 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. Students discover that states, companies, and industry groups selectively use figures which make themselves look good.

The last part of the assignment required students to cite sources. Most students learned how to write citations in a previous English or Communications class, using complete http addresses with access dates. We reviewed citation requirements in class.

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, such as mirror backs for telescopes and high-power lasers.

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. This topic leads to a discussion of materials for green-building.

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](image-url)

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. Students learn to use graphs as tools for critical thinking.

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)

Most of my students grew up in greater Fort Wayne, and many of them know employees of the magnet wire plants. 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 also made in Fort Wayne.

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 a conventional 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.)

Braking is a rare event when a vehicle is driven for long distances at highway speeds, so highway fuel economy is not improved by hybrid engine systems. The significant factors are wind resistance and engine efficiency.
I follow Figure 2 with a graph of the cost of gasoline over time:

![Graph showing the cost of gasoline over time from 2001 to 2008.](image)

**Figure 3:** Cost of regular unleaded gasoline (current dollars). 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 an average of 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 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 with 83 students, and two measures of student opinion (166 opportunities for response), 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. Several homework questions helped students learn to treat internet data with skepticism, and to double-check facts.

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.\textsuperscript{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;\textsuperscript{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.

References

\begin{enumerate}
\item Kalpakjian & Schmid, \textit{Manufacturing Engineering and Technology}, 5\textsuperscript{th} ed., Prentice Hall, 2006.
\item The U.S. Geological Survey issues annual reports on more than seven dozen nonfuel minerals and metals, available at \url{http://minerals.usgs.gov/minerals/pubs/mcs/}.
\item Data from the author’s purchases of gasoline, primarily in northern Indiana.
\item Light, R. \textit{Making the Most of College}, Harvard University Press, 2001, p. 52-53.
\item The Copper Development Association has some particularly good microstructures of copper alloys at \url{www.copper.org}.
\end{enumerate}