TEACHING AND LEARNING PORTFOLIO

by

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Delta Program in Research, Teaching, and Learning
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Adam Creuziger

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Teaching Philosophy

I have been a college student in engineering for 9 years now. As I consider being on the other side of the desk, I've thought about my own education. I have had a number of excellent classes, and a number of others courses that could be improved upon. As I start to develop my own courses, I want to improve on the education I've received. I would like to structure my courses around the goals that my students and I have. I want the courses I create to challenge biases and normalized behavior. Diverse learning styles will also be incorporated to reach more students and broaden the experiences of those in my courses. There are a number of different ideas I'd like to try, and it's important to keep track of these ideas and assess how well they work or don't work. The process of evaluating these ideas is the same process that technical research requires; forming a hypothesis, developing a test of that hypothesis, analyzing the results of the test, and making conclusions based upon the analysis.

I believe that courses should be designed based upon what learning goals we have for the students. This differs from a traditional engineering course where the emphasis is on covering content. Currently, the content of the engineering course is viewed as a 'toolkit' that the students will be able to apply to problems they will encounter in the future. This is the opposite of what typically occurs in engineering practice. You usually encounter the problem first, and then explore possible methods and develop a solution. By taking the emphasis off building the toolkit for the students and setting the learning goal that the students be able to develop their own toolkit, we change how engineering education is approached. This mimics how engineering problems are dealt with in practice. This also allows for more collaboration with the students to develop learning goals instead of prescribing content for them.

If you look into an archetypal engineering course, many things may initially strike you. A course is mainly composed of a textbook, lecture on the topics in the textbook, and homework and exams based on those topics. The classroom will be predominately male, and usually led by a male professor. This has been how engineering courses have been taught for many years. These three observations reflect on similarity of learning styles, conscious and unconscious bias of gender and normalization of behavior. These observations can be countered with the same technique, by increasing diversity. Questioning why we assume this is the typical engineering course structure and looking for alternative solutions is disruptive to normalization. This mirrors good engineering practice. Challenging the assumptions inherent in bias is similar to challenging assumptions in a model or experiment. Teaching from different learning styles will allow students who have difficulty with the current style to be more successful in the classroom, which is also an example of finding alternate solutions and challenging assumptions.

I have set forward a few different ideas I have for engineering courses in this philosophy. As an engineer, I view each one of these ideas as a hypothesis, with the expectation that the changes I've made in the structure of a course will be helpful to students. The skills used as an engineer: forming a hypothesis, devising a test, analyzing the results and sharing the results with others do not need to be tossed out simply because you've entered a classroom. Educational literature can be consulted to help direct the course modifications, assessment and analysis. If the hypothesis is proven others could use the data, if not, other changes in the course can be considered. After the results are analyzed, the results can be discussed with peers and/or published. This is the same method that is pursued in ‘technical’ engineering research. The skills are there, there isn’t a need to compartmentalize and take off the ‘research hat’ and put on the ‘teaching hat’.

These are the goals I have when I get to a classroom, but they can also be used for technical research. In engineering we are constantly sharing ideas and communicating with each other. By learning and developing teaching skills, we can make this process faster and more clear. As a teacher I want to continue to learn and develop my teaching skills. Learning should not stop when you leave the classroom, or when you switch sides of the desk.

Planning a Content Driven Course

Artifact {1} is an excerpt of a course portfolio I prepared. This course portfolio is built on the course content I wanted to cover. This course focuses on ethics and technology assessment as applied to nanotechnology. This was created as part of the course “Seminar in Nanotechnology and Society: Analytical and Pedagogical Approaches”. The seminar focused on preparing an undergraduate course on nanotechnology and society. An annotated syllabus, daily course plans and exam questions were included in a course portfolio at the end of the seminar. The course I developed was not taught, but served as my initial experience with course planning.

Prior to my involvement in this seminar, I thought that teaching was mainly a matter of deciding what would be covered that day. I would be easy to stand up in front of the class with a general idea of the content you wanted to cover; the specifics would come out as you talked. If you knew the content well enough you didn’t need to prepare anything.

I found that developing a course was a lot more work than I had expected. Even the relatively simple task of choosing the texts for readings was much more complicated than I had expected. I ended up choosing selections from 17 different texts, since I couldn’t find one that contained what I wanted. The course I ended up creating was more of an advanced or graduate level course. I was encouraged to follow this path, but it didn’t meet the expectations of the seminar. It also took me some time to appreciate the value of course plans. I didn’t understand why I needed to do them; I knew what was going to be covered and I was sure that when I got in front of a class everything would work out.

Fortunately I had the opportunity to outgrow how naïve I was before I got into a classroom. Looking at the reading list and syllabus I’ve developed, I still think it would be an interesting course to teach. It’s quite dense, and I’ve learned that the amount of content I planned to cover isn’t realistic to expect the students get much out of it.

Looking back, I particularly like the final exam question I wrote. It nicely combines the idea of developing a toolkit of different ethical frameworks and technology assessment while providing a direction for what this knowledge could be used for. However, looking back on my course plans, I didn’t have any plans on how I would effectively measure what the students ‘learned’ about ethics or technology assessment. If I were teaching this class now, I’d develop a rubric that would be provided with the question. The most heavily weighted categories would be: clarity of their choice of regulation on nanotechnology, thoroughness of ethical evaluation and thoroughness of technology assessment.

One of the things I’ve gained through developing this course and participation with the Delta program is an appreciation for how much planning teaching requires. I’ve learned that course plans offer an opportunity to get your ideas down on paper. This way you can determine if your plan for the day will meet the expectations you have for the students. You then have the course plan after the class so that you can critique how well or poorly your plan worked out in practice and write comments to build upon. You can also examine the methods you used and consider trying other methods. These plans and comments can be shared with others to help them develop their own courses.

Preparing an Ethics Bowl Team using Goal Oriented Teaching

Frequently courses are directed based on what content needs to be covered. The course I developed on ethics and technology assessment applied to nanotechnology is an example of this structure. Through my experiences with the Delta program, I've come to question that this is an effective structure. I believe more thought should be placed on what goals we have for the students after participating in the course. This may seem like a subtle shift, but I think the distinction is important. Instead of the focus being on making sure the content is presented, the emphasis is on setting and attaining goals for what the students have learned.

I tried a goal-oriented approach in preparing the UW-Madison Ethics Bowl team. Ethics Bowl is an intercollegiate debate competition where a team is given 15 'cases' to study in advance. Each case provides a context for an ethical dilemma [1]. At the Ethics Bowl, each team is presented with a question on one of the cases and is asked to defend their answer. When the other coaches and I first met, we devised 3 goals for ourselves and the team:

1. To form a team and be competitive at the regional ethics bowl.
2. To make learning about ethics and competition at the regional ethics bowl a fun and positive experience
3. To give the students a background in different ethical systems and to be able to articulate what ethical system led them to a conclusion about each case.

In this case, the first and third goals would be evaluated by getting a team to ethics bowl and their judged performance at ethics bowl. A post ethics bowl survey would determine if the students viewed this as a fun and positive experience.

Structuring preparation around these goals worked well. Preparation for the ethics bowl was discussion based and the goal structure allowed flexibility from having a rigid set of items to cover. I developed a plan for each session iteratively based upon what we covered the previous session and how well aspects of the discussion went. The content of the discussion was focused on meeting those goals. We did get a team together and participated in the ethics bowl, meeting the first goal. Artifact {2} is the collected responses from that survey from three of the four participants. All of them have positive comments about participating, which shows we met the second goal. Our scores and ranking by the judges was 7th out of 13 teams, which indicates that the students met the third goal.

Compared to the method of creating content first, I like the structure of setting goals better. It seems easier to create content based on goals than to determine what goals you are meeting by covering the content. By writing the goals down first it is possible direct the content based upon those goals.

However, I noticed some problems with the goals we set and how we assessed them. The first goal we set should actually be separated into two separate goals, participation and competitiveness. I don't want to emphasize the competitive nature; I'd rather this be a learning experience, so I think a goal of improving on last year's performance is reasonable if it does not have high priority. I still want to include a goal of making ethics bowl a positive experience, and I think a survey afterward is a reasonable way of assessing this. I think the attitude towards a material helps sustain long-term learning, but I don't think this should be as high of goal as learning about different ethical perspectives. The third goal is again two separate ideas; having a good background in ethics and good articulation of ethics. Being able to articulate their ethical viewpoints is something that the judges at Ethics Bowl assess, but the background they have in ethics isn't directly assessed. I noticed at Ethics Bowl the students relied heavily on two ethical frameworks, deontological and utilitarian. There are many more frameworks that can and should be considered in their arguments. I would like them to be more familiar with a wider variety of frameworks, and will work with the current coaches to devise some type of formal or informal assessment for this. The revised goals and assessments would be as follows:

1. Form a team and participate in Ethics Bowl.
   Assessment: Participation at Ethics Bowl
2. Be able to consider different ethical perspectives of a situation.
   Assessment: Evaluated by the coaches during practices
3. Be able to articulate a decision based upon the ethical perspectives of a situation.
   Assessment: Evaluated by the judges at Ethics Bowl
4. Make learning about ethics and the competition at ethics bowl a positive experience.
   Assessment: A post-Ethics Bowl qualitative survey asking them to describe their experience learning about ethics and the Ethics Bowl competition.
5. Improve performance from last year
   Assessment: Ranking better than 7/13 in the 2007 Regional Ethics Bowl

The Forces of Unconscious Bias and Normalization

Artifact {3} is the Women In Science & Engineering Leadership Institute (WISELI) pamphlet “Reviewing Applicants – Research on Bias and Assumptions” [2]. This pamphlet includes much of the content discussed as part of Jenn Sheridan’s presentation on Nov 3rd at an American Society for Engineering Education (ASEE) UW-student chapter meeting. This pamphlet talks about and provides references for a variety of unconscious biases that occur and techniques to reduce or avoid these biases.

A study that was presented as part of this discussion is the work by Biernat (1991) [3]. In this study, men and women were put in a doorframe and photographed. When asked to estimate the height of the person in the doorframe, men’s heights were over-estimated and women’s heights were underestimated, regardless of the gender of the evaluator. This study in particular has stuck with me. As an engineer I deal with a lot of measurable and quantitative results. In Biernat’s study an objectively measurable value, height, was placed in a doorframe that provided a constant frame of reference for the evaluator. Having an objectively measurable quantity with this constant frame of reference is a best-case scenario. Even in a best-case scenario like this, unconscious bias affects the assessment of height. In this case, with an objective measure like height, the evaluator’s assessment can be challenged easily. All persons being evaluated could be compared side by side since the doorframe does not change. If asked to evaluate a more subjective measurement, like ‘ability’, it is more difficult to challenge that assessment.

Another concept that came out of this series of discussions at the ASEE UW-student chapter meetings was the concept of normalization. The book by Diane Vaughn about the Challenger disaster [4] was discussed as an example of normalization. The book goes through the Challenger disaster as an ethnography, trying to understand the culture that lead to the decision to launch. Vaughn discusses how statements and practices at NASA, the consulting firms and contractors created a normalization of deviance. Normalization of deviance is a practice where events that weren’t initially expected are categorized as ‘normal’ instead of being investigated. This normalization of deviance occurred in part because of how problems were addressed and in part due to general engineering mind-sets and practices.

Vaughn’s book has led me to see aspects of engineering in a different light. In engineering it is commonplace to accept something that works, without always understanding the details of how it works and why. The adage “if it isn’t broke, don’t fix it” is quite common in engineering even if something doesn’t work well. There is also institutional inertia and practices that prevent adapting a new viewpoint or questioning practices. These represent pressures of normalization.

I mention the two concepts of unconscious bias and normalization together because I believe that diversity can be used to reduce both of these effects. Bias and normalization are similar in that they are systematic problems that can marginalize groups of people or opinions. Diversity can be used to reduce these effects by bringing people together to challenge the assumptions and opinions. It is important to challenge both biases and normalization by asking ‘why is that’ instead of saying ‘that’s the way it is’. To help challenge both concepts we need to create more objective measurements, consider other viewpoints, increase diversity and make others aware of theses issues. By being aware of unconscious bias and normalization we can begin to work against them.

In the future I will most likely be involved with evaluating candidates for a position, which is what the WISELI pamphlet primarily deals with. One way to reduce bias is to create some objective measures when evaluating people and stick to them. This help will reduce the effect of unconscious bias, and is also disruptive of normalization by changing the criteria of evaluation and making people aware of bias. This also applies in the classroom, by create some objective measures and checking to ensure bias does not creep into the methods.

Teaching by Including Diverse Learning Styles

In addition to cultural and gender diversity there is also diversity of learning styles. One of the more popular descriptions of learning styles, VARK, has four categories: visual, aural, read/write and kinesthetic [5]. I was introduced to the idea of different learning styles in the Instructional Materials Development (IMD) course offered by the Delta Program. As part of the IMD course I decided to create a kinesthetic demonstration for an introductory mechanics of materials course.

I came to realize during the IMD course that most engineering courses rely heavily on text, pictures or speech. Students who prefer to learn in different ways may struggle. I choose a kinesthetic demonstration because kinesthetic seemed the least represented learning style in a typical course. Based on my initial survey data from my ASEE paper (full survey data is discussed in more detail in artifact {5}), I choose to make an example of single and double shear. An image of the demonstration and instructions for use is given in artifact {4}. The idea is that you can feel that more force is required to break a sample in double shear than is required to break a sample in single shear. The student could estimate how much more force is required or measure with a spring scale. This demonstration was designed to be included in an introductory mechanics of materials course.

I feel that I learned a lot from designing and creating this demonstration, even though I would not consider it to be a success. The demonstration didn’t get included as part of the introductory mechanics of materials course. I realize now that in a classroom of 80+ students it’s difficult to include demonstrations like this. However, I would like to explore including the demonstration for smaller lectures or discussions. It was suggested that I replace the teflon tape with spaghetti noodles, which would make the fracture more representative of engineering materials. If I were to use this in the future, I would work on developing some assessment techniques to evaluate if this demonstration was successful at helping students understand the double and shear stress from a new perspective.

I have also encountered different learning style models, such as multiple intelligences [6] and the Felder-Silverman learning styles [7]. Similarly to the VARK analysis, engineering curriculum tends be slanted toward a few learning styles in these models. I would like to provide a more balanced education, not only so the students learn from different angles, but also to teach to students who learn differently that I do.

Teaching as Research

Artifact {5} is a paper that I wrote, presented and was published as part of the American Society for Engineering Education (ASEE) 2006 Conference. The paper was based on a survey I created and applied to students in an introductory mechanics of materials course. Instructor comments had indicated shear stress was a particularly difficult subject for students. We hypothesized that there would be a single underlying difficulty, with the goal of creating or changing instructional material to address that difficulty. The voluntary survey was provided to two semesters of students ten weeks into the course.

The questions on the survey were a mix of quantitative questions and qualitative questions. The quantitative question #3 was aimed at gauging the student's assessment of their abilities in dealing with shear stress. Question #7 asked what parts of the course helped them the most, and was intended to identify the parts of the course that could use improvement. Questions #4 and #5 were qualitative and simply asked the students to identify the concept they thought they had the most difficulty with and understood best respectively. Question #6 asked them to explain the concept of shear stress in their own words.

The responses to the quantitative questions indicated that the difficulty students are having with shear stress is between using equations and expressing the concept of shear stress to a peer. While this data is useful in identifying the problem, it doesn't give any indication of how to improve this problem. Similarly, the quantitative data on what parts of the course are useful to the students indicates that homework is most helpful, followed by lecture, discussion and the textbook. But it doesn't indicate why these are helpful or what would improve them.

The qualitative data was more useful. The student responses were put into topic categories generated by the responses and binned in those categories. Initially, (as discussed in the previous reflection) the results indicated that single and double shear were the most difficult. However, upon repeating the survey, our initial hypothesis was proven incorrect by the data. Instead of one category that stood out as an underlying difficult subject, there was a broad distribution of subjects students found difficult. Interestingly many of the same categories appeared on the lists of most difficult concept and the concept understood best. This indicates that some type of peer teaching might be effective at helping students if we can connect the students that are having difficulty with a concept and those that understand the concept well. The qualitative aspect of the data helps by not only getting insight into what is happening, but also includes a direction to try next time.

I've created and applied surveys a few other times since this paper. The qualitative questions give deeper responses and help give more direction for improvement than the quantitative questions. Quantitative questions do have their place; they are useful in checking for the presence or absence of a problem or another type of yes or no question. However, they are not likely to give you any insight into what to do if there is a problem. The difficulty of qualitative questions is that they do take more time to analyze.

This paper is an example of research into education. While many would be satisfied with this paper, there are a number of changes I would make in the future. A goal I would have as an instructor would be to apply this survey repeatedly, making modifications to the course each semester and seeing how they turn out. A number of questions on the survey could also be improved. I would change the question about which part of the class is most helpful to a qualitative response on what is most and least helpful. That would provide more insight into what action could be taken to improve the course. I'm not sure that asking the students to describe shear stress in their own words was a useful question. Asking at what point when they are describing shear stress to a peer they have the most difficulty would give insight into what particular problem they have.

References

[1] Ladenson, Robert. “Ethics Bowl.” 2007 Illinois Institute of Technology Accessed: 9 July 2007. <http://ethics.iit.edu/eb/index.html>

[2] WISELI (Women in Science and Engineering Leadership Institute) “Reviewing Applicants: Research on Bias and assumptions.” 2006 University of Wisconsin Madison. Accessed: 9 July 2007. <http://wiseli.engr.wisc.edu/initiatives/hiring/BiasBrochure_2ndEd.pdf>

[3] Biernat, M. et al., Journal of Personality and Social Psychology 60 (1991).

[4] Vaughan, Diane. “The Challenger launch decision: risky technology, culture, and deviance at NASA.” University of Chicago Press, 1997.

[5] Fleming, Neil “VARK- A Guide to Learning Styles.” 2001 Accessed: 9 July 2007. <http://iliad.cats.ohiou.edu/vark/>

[6] Wikipedia “Theory of multiple intelligences.” Last modified 18:37, 7 July 2007, Accessed 9 July 2007. <http://en.wikipedia.org/wiki/Theory_of_multiple_intelligences>

[7] Felder, R. M. “Learning Styles.” Accessed 9 July 2007. <http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Learning_Styles.html>

Artifact {1}
Excerpts from the course: Nanotechnology: A Case Study of Ethics and Technology Evaluation Methods

Syllabus for Weeks 1-5

Week 1

Monday: Class Introduction

Wednesday: Plagiarism and Respect for Others

“Tips for Teachers: Encouraging Students in a Racially Diverse Classroom” Derek Bok Center for Teaching and Learning, Harvard University

“Women and Men in the Classroom: Inequality and Its Remedies” Krupnick, Catherine G. Derek Bok Center for Teaching and Learning, Harvard University. http://bokcenter.harvard.edu/docs/krupnick.html

“Quoting and Paraphrasing Sources” The Writing Center, the University of Wisconsin-Madison. http://www.wisc.edu/writing/Handbook/QuotingSources.html

Friday: What is Technology?

Week 2

Friday:	Political Implications of Technology		
	SST	*Do artifacts have politics?*	p28-39
Monday:	How Technology Affects Society		
	SST	*Introductory Essay*	p3-26
	ASHT	*Epilogue*	p700-711
Wednesday:	Social effect on Technology		
	EAT	*Views of Technology*	p3-25

Week 3

Monday:	Examples of Nanotechnology		
	IEMN	*Introduction*	p20-40
Wednesday:	Nanotechnology & Nanoscale		
	NGI	*Introducing Nano*	p2-9
	NGI	*Size Matters*	p11-18
Friday:	Social Effects on Nanotechnology		
	JNR	Broader Societal Issues of Nanotechnology	V5 p181-189
	Testimony to congress	Langdon Winner	

Week 4

Wednesday:	Paper Questions		
Friday:	Introduction to Ethics		
	RECM	*General Issues & Introduction*	p3-26
	21C	*Ethics as a Learning Experience*	p9-20, 29-32
Due:	How technology & society interact (paper)		

Week 5

Monday:	Utilitarian Ethics		
	EPD	*Utilitarian Calculation*	p13-32
	UPP	*Utilitarianism as a Public Philosophy*	p3-32
Wednesday:	Utilitarian ethics: RFID		
	Group 1 (1/8) finds articles		
Friday:	Utilitarian ethics: Nanosensors		
	IEMN	*Sensors*	p80-98

Example Daily Course plan:
Week 1, Day 3
What is technology?

Session Goals

Discuss examples of technology and develop a working definition of technology.

Due: an example of 'technology'

1. Examples of Technology (15 min)

Each student will come to class with an example of 'technology'. We will list these examples on the board. If there is extra time, additional examples can be generated as a 'brainstorm'. I will also provide a few examples to consider

This will encourage the students to vocally participate and ensure that those quiet students have a chance. Also encourages some preliminary analysis of what technology is.

2. Working Definition of Technology (35 min)

From these examples, we will try to develop a working definition of technology. The students have an intuitive sense from their examples. If necessary, will apply the leading questions: Is it science? Is it machinery? Is it a social construct?

Final Exam Question:
Given what you know about nanotechnology, how should we proceed? (final)

Take the role of an interested citizen in nanotechnology. What regulation would you request and from which government body, what nanotechnology should be released to the public, what role should the government have. Support your case with an ethical evaluation and an assessment evaluation.

Final Paper
Assigned on the last day of class, due 1 week later. The final paper will be 6-8 pages (double spaced, with 1 inch margins, 12 point font)

Artifact {2}
Ethics Bowl Survey Responses from Participating Students

I'd like to know your thoughts about the Ethics Bowl, both for my own information and to give notes for whoever may be coach for the Ethics Bowl next year. I was hoping that you could spend a bit of time to write down your reactions to the ethics bowl. I have three questions below that I'm particularly interested in your thoughts on, but feel free to comment about anything. (I was thinking about a half page or so)

1. What did you like best about preparing for the ethics bowl?
2. What would you change in the future?
3. What have you learned about ethics?

I am planning on receiving a certificate in research, teaching and learning through the Delta program (www.delta.wisc.edu). As part of that process, I will be putting together a teaching portfolio that summarizes some of the work I have done. I may be including these responses in that portfolio, without any identifiers (so your name and anything else that could be used to identify you will be removed). This is a voluntary survey. If you have any objections or questions, please let me know.

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In preparing for the ethics bowl, I liked the fun atmosphere and open forum that we had each week. Learning about ethics, discussing cases, and even arguing at times was always enjoyable. And each week I left the meeting understanding more about ethical frameworks and how they can be applied. Feeling as though everyone was learning together and being able to talk freely and openly was key. As for things in the future, I feel my arguments and how I structured my ethical responses improved most when I actually presented my case for the rest of the group. I think next year more time should be focused on this aspect.

Overall, I learned that ethics is not simply the study of right and wrong. Previously, I thought that some actions are ethically right, and others clearly are not. However, I have learned that using the tools of ethics, every action can not only be designated as right or wrong, but can be any shade in-between. Ethics only gives you different lenses through which to study actions and decisions.

I'd like to know your thoughts about the Ethics Bowl, both for my own information and to give notes for whoever may be coach for the Ethics Bowl next year. I was hoping that you could spend a bit of time to write down your reactions to the ethics bowl. I have three questions below that I'm particularly interested in your thoughts on, but feel free to comment about anything. (I was thinking about a half page or so)

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1) I likedhow it was a relaxed setting throughout the whole process,
we were just to do the best we could, and we took everything onestep at
a time. We divided the cases up in a fair manner and every team member
had an equalchance to argue their point + ask questions.
It was great to have experenced coaches, so I felt tortally prepared, I just had
to come through with myown mastery of the subject matter. The practice Bowl
With Edgewood College helped immensely. The snacks were wonderful also!
2) Maybe after reading parts of the book we could spend some time understanding the
frameworks discussed, because I'd never encountered them before. I think exploring more
about what the frameworks mean will helpus argue our cases + how they apply
-Have a team of 5 to have one more point of view + to split the cases up so each person has
less cases and they can focus on them more. (I know this does depend on interest) But number doesn't really matter
-Somehow make it count for 1 credit
3). I learned that to have a great arguement you need solid facts + reasoning. I couldn't believe
the number of frameworks that try to explain basically what causes us to act like we do,
what influences our motives + how different societies interpret actions as either good or bad.
-Also, how many daily stories + situations around me present ethical challenges + dilemmas.
-I give tons of credit to those people who are in jobs and positions that actually
have to "solve"/make ethical decisions daily that will affect others.

Thanks so much!

1. What did you like best about preparing for the ethics bowl?

The best part about preparing for the ethics bowl was definitely just being able to get together with people for two hours a week. It was a nice break from all of the big lectures and other classes. I liked being in a small group to discuss the certain topics. I know there was talk about expanding the group, but I personally liked the intimacy of it. I liked being able to get together with intelligent people to talk about real issues. The people were ones who wanted to be there and actually thought about all of the discussions. You rarely get that in a classroom setting. I really liked the fact that there wasn't a lot of pressure. In a lot of settings like this one, the instructor is forced to put pressure on the students just to make them do their work/research. In this case, we weren't forced to be perfect, but we still did research and other work on our own. This kind of approach was really helpful, and it worked with the people who were involved. I can't say that I liked the "pop quizzes," but they definitely helped in preparing for the real ethics bowl. I think that it was good to do a couple practice rounds because it forced us to not get a plan ready before we went, but rather be ready for any question.

2. What would you change in the future?

There isn't a lot I would change for the future. First of all, I'd probably start earlier (difficult for us I know.) I guess I would set more deadlines for each week saying what we were going to do ahead of time, and then once in a while (not too often) spring an extra practice round on us, just to keep us on our toes. I liked getting the feedback from the former judges, and that was really helpful, so making sure Sarah, Mark, and Laura are included in the discussion and doing the practice with Edgewood is really important.

3. What have you learned about ethics?

I've learned a lot more than I ever imagined I would. I learned that it's not just something I feel, but it actually has "rules." Before being involved in this team, I had very strong feelings about many different issues just because they were my beliefs. Walking away from ethics bowl, I was able to state why I had such strong feelings. I think that the things I learned by being involved in this team were things I never knew existed, and probably wouldn't know either. Its funny how since ethics isn't a requirement to learn, I haven't really heard of the technicalities before.

Overall, I'm really pleased with the outcome of this whole experience. I'm really glad that I took this challenge. It was a fun way to express my feelings and talk with other people about real issues. I really had a good time researching my cases, as they were pretty interesting. In high school we did a debate for one of my classes, and I loved it. I got to research a topic with opposing viewpoints, and then prepare an outline, stand in front of my peers and explain to them why I was "right". I've never wanted to be on a debate team because it's too nerve-racking, which is why the ethics bowl team was the perfect fit for me! I've gained a deeper understanding of the word "ethics" and I've become more apt to think about them in everything I do. I had a great time, and I hope to continue in the future!

Artifact {3}
Women In Science & Engineering Leadership Institute (WISELI) pamphlet

http://wiseli.engr.wisc.edu/initiatives/hiring/BiasBrochure_2ndEd.pdf

We all like to think that we are objective scholars who judge people solely on their credentials and achievements, but copious research shows that every one of us has a lifetime of experience and cultural history that shapes the review process.

> *"To evaluate other people more accurately we need to challenge our implicit hypotheses … we need to become explicitly aware of them."*
>
> Virginia Valian

The results from controlled research studies demonstrate that people often hold implicit or unconscious assumptions that influence their judgments. Examples range from expectations or assumptions about physical or social characteristics associated with race, gender, and ethnicity to those associated with certain job descriptions, academic institutions, and fields of study.

It is important to note that in most studies examining evaluation and gender, ***the sex of the evaluator was not significant; both men and women share and apply the same assumptions about gender.***

Recognizing biases and other influences not related to the quality of candidates can help reduce their impact on your search and review of candidates.

Examples of common social assumptions or expectations:

- When shown photographs of people of the same height, evaluators overestimated the heights of male subjects and underestimated the heights of female subjects, even though a reference point, such as a doorway, was provided (Biernat et al.).

- When shown photographs of men with similar athletic abilities, evaluators rated the athletic ability of African American men higher than that of white men (Biernat and Manis).
- When asked to choose counselors from among a group of equally competent applicants who were neither exceptionally qualified nor unqualified for the position, students more often chose white candidates than African American candidates, indicating their willingness to give members of the majority group the benefit of the doubt (Dovidio and Gaertner).

These studies show that we often apply generalizations that may or may not be valid to the evaluation of individuals (Bielby and Baron). In the study on height, evaluators applied the statistically accurate generalization that on average men are taller than women to their estimates of the height of individuals who did not necessarily conform to the generalization. If generalizations can lead us to inaccurately evaluate characteristics as objective and easily measured as height, what happens when the qualities we are evaluating are not as objective or as easily measured? What happens when the generalizations are not accurate?

"Even the most well-intentioned person unwittingly allows unconscious thoughts and feelings to influence apparently objective decisions."

MAHZARIN R. BANAJI

Examples of assumptions or biases that can influence the evaluation of applications:

- When rating the quality of verbal skills as indicated by vocabulary definitions, evaluators rated the skills lower if they were told an African American provided the definitions than if they were told that a white person provided them (Biernat and Manis).
- Randomly assigning different names to résumés showed that job applicants with "white-sounding names" were more likely to be interviewed for open positions than were equally qualified applicants with "African American-sounding names" (Bertrand and Sendhil).

"To respond without prejudice … an individual must overcome years of exposure to biased and stereotypical information."

PATRICIA DEVINE ET AL.

- When symphony orchestras adopted "blind" auditions by using a screen to conceal candidates' identities, the hiring of women musicians increased. Blind auditions fostered impartiality by preventing assumptions that women musicians have "smaller techniques" and produce "poorer sound" from influencing evaluation (Goldin and Rouse).
- Research shows that incongruities between perceptions of female gender roles and leadership roles cause evaluators to assume that women will be less competent leaders. When women leaders provide clear evidence of their competence, thus violating traditional gender norms, evaluators perceive them to be less likeable and are less likely to recommend them for hiring or promotion (Eagly and Karau; Ridgeway; Heilman et al.).

Examples of assumptions or biases in academic job-related contexts:

- A study of over 300 recommendation letters for medical faculty hired by a large U.S. medical school found that letters for female applicants differed systematically from those for males. Letters written for women were shorter, provided "minimal assurance" rather than solid recommendation, raised more doubts, portrayed women as students and teachers while portraying men as researchers and professionals, and more frequently mentioned women's personal lives (Trix and Psenka).
- In a national study, 238 academic psychologists (118 male, 120 female) evaluated a curriculum vitae randomly assigned a male or a female name. Both male and female participants gave the male applicant better evaluations for teaching, research, and service experience and were more likely to hire the male than the female applicant (Steinpreis et al.).
- A study of postdoctoral fellowships awarded by the Medical Research Council of Sweden found that women candidates needed substantially more publications to achieve the same rating as men, unless they personally knew someone on the panel (Wennerås and Wold).

When we assume "that cultural, racial, ethnic, and gender biases are simply nonexistent [in] screening and evaluation processes, there is grave danger that minority and female candidates will be rejected."

Caroline S.V. Turner

Advice for minimizing the influence of bias and assumptions:

- **Strive to increase the representation of women and minorities in your applicant pool.**
  Research shows that gender assumptions are more likely to negatively influence evaluation of women when they represent a small proportion (less than 25%) of the pool of candidates (Heilman).
- **Learn about and discuss research on biases and assumptions and consciously strive to minimize their influence on your evaluation.**
  Experimental studies show that greater awareness of discrepancies between the ideals of impartiality and actual performance, together with strong internal motivations to respond without prejudice, effectively reduces prejudicial behavior (Devine et al.).
- **Develop evaluation criteria prior to evaluating candidates and apply them consistently to all applicants.**
  Research shows that different standards may be used to evaluate male and female applicants and that when criteria are not clearly articulated before reviewing candidates evaluators may shift or emphasize criteria that favor candidates from well-represented demographic groups (Biernat and Fuegen; Uhlmann and Cohen).
- **Spend sufficient time (at least 20 minutes) evaluating each applicant.**
  Evaluators who were busy, distracted by other tasks, and under time pressure gave women lower ratings than men for the same written evaluation of job performance. Sex bias decreased when they were able to give all their time and attention to their judgments, which rarely occurs in actual work settings (Martell).
- **Evaluate each candidate's entire application; don't depend too heavily on only one element such as the letters of recommendation, or the prestige of the degree-granting institution or post-doctoral program.**
  Recall the study showing significant patterns of difference in letters of recommendation for male and female applicants (Trix and Psenka).

- **Be able to defend every decision for eliminating or advancing a candidate.** Research shows that holding evaluators to high standards of accountability for the fairness of their evaluation reduces the influence of bias and assumptions (Foschi).
- **Periodically evaluate your judgments, determine whether qualified women and underrepresented minorities are included in your pool, and consider whether evaluation biases and assumptions are influencing your decisions by asking yourself the following questions:**
  - ❒ Are women and minority candidates subject to different expectations in areas such as numbers of publications, name recognition, or personal acquaintance with a committee member? (*Recall the example of the Swedish Medical Research Council.*)
  - ❒ Are candidates from institutions other than the major research universities that have trained most of our faculty being undervalued? (*Qualified candidates from institutions such as historically black universities, four-year colleges, government, or industry, might offer innovative, diverse, and valuable perspectives on research and teaching.*)
  - ❒ Have the accomplishments, ideas, and findings of women or minority candidates been undervalued or unfairly attributed to a research director or collaborators despite contrary evidence in publications or letters of reference? (*Recall the biases seen in evaluations of written descriptions of job performance.*)
  - ❒ Is the ability of women or minorities to run a research group, raise funds, and supervise students and staff of different gender or ethnicity being underestimated? (*Recall social assumptions about leadership abilities.*)
  - ❒ Are assumptions about possible family responsibilities and their effect on a candidate's career path negatively influencing evaluation of a candidate's merit, despite evidence of productivity? (*Recall studies of the influence of generalizations on evaluation.*)
  - ❒ Are negative assumptions about whether women or minority candidates will "fit in" to the existing environment influencing evaluation? (*Recall students' choice of counselor.*)

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WISELI

Women in Science & Engineering Leadership Institute

University of Wisconsin-Madison

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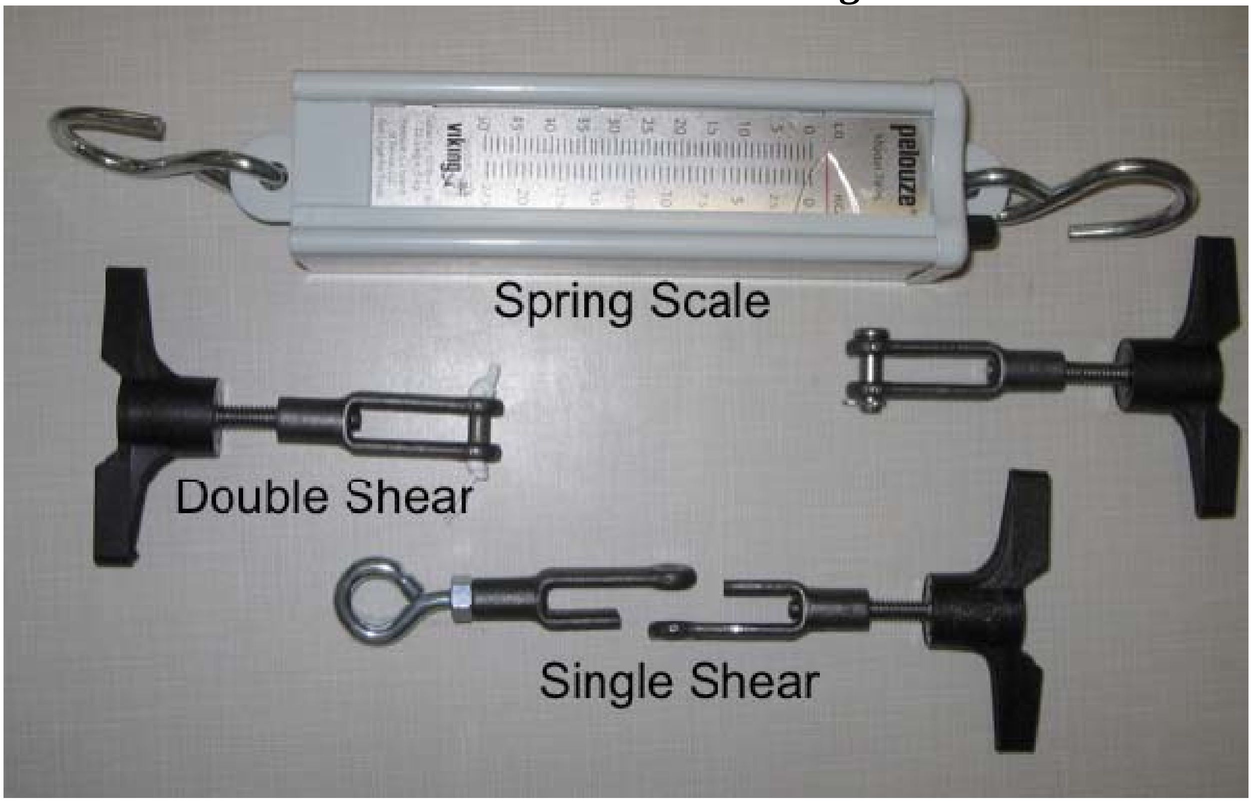
Artifact {4}
Kinesthetic Demonstration on Double and Single Shear



Demonstration materials that can be used as an in lecture experiment.

A 3/32" Teflon 'rod' is placed in the clevis and held on either end with a knot. The clevis is connected to the spring scale and pulled from either end by two people. A third person is required to observe the maximum load. In the image, the Teflon rod is shown in the double shear clevis, but the single shear clevis is empty. The additional clevis is used to hold onto the spring scale.

It's worth noting that the Teflon is the only consumable part. I purchased these components from McMaster-Carr. Complete details of the components, prices (as of 10 May 2005) and stress calculations are listed in Appendix C.

The topic of double shear is covered in lectures 5 and 6. At the end of lecture 5, after the concept of single and double shear in bolts is introduced, four students will be selected to assist in the demonstration. With a video camera focused on the spring scale projecting to the entire class, the students will pull on the sample until it fractures in single shear. The load at fracture will be recorded. A second pair will pull on the sample loaded in double shear. The load at fracture will again be recorded. The loads should be different by a factor of two. After this example, a short handout will be distributed with a few questions to answer for the next class. Students will work on the handout in groups. At the beginning of the next class a concept question building on the handout will be asked using the student response system. After the concept question is asked, a mathematical example will be worked out in class using the same material as used in the demonstration. If possible, difficulties on the concept question will be addressed during the example.

Artifact {5}
Paper published in 2006 ASEE Conference Proceedings

Difficulties with Shear Stress in Introductory Mechanics of Materials

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Abstract

Shear stress is a difficult concept for students when it is first encountered in mechanics of materials. Whether this difficulty is due to a single fundamental difficult topic, a variety of difficult topics, or some other factor has not been addressed in the literature. A student survey and student interviews were conducted in an introductory mechanics of materials course mid-semester to get more specific answers from the students as to difficulties and aids in understanding the concept of shear stress. Responses to which shear stress concept they ‘understood best’ or ‘had the most difficulty with’ were quite varied with many concepts appearing on both lists. Respondents’ replies to how they would explain shear stress to another person offer insight into how students understand shear stress as a whole. This data indicates that here does not seem to be a single underlying cause to the difficulties that students have with shear stress. The distribution of the difficulties implies that peer teaching may be an effective method to reduce the difficulty of these concepts.

Background

The topic of focus for this paper is the concept of shear stress, as taught during an introductory Mechanics of Materials course. Shear stress is stress that occurs tangentially to a plane of interest. Many engineering materials fail in shear, so understanding this concept is critically important to good engineering design. Shear stress, based on teaching experience, appears to be a difficult concept for students. Whether this difficulty is due to a single fundamental difficult topic, a variety of difficult topics, or some other factor has not been addressed in the literature. Because the teaching methods used in this course are similar to how mechanics of materials is taught nationally, the survey results of the study discussed below should be broadly applicable.

There are a variety of methods that can be used to determine what concepts are difficult for students. For many disciplines, concept inventories have been used to determine what concepts are most difficult for students. A concept inventory for mechanics of materials (strength of materials) has been developed [1-3]. From this concept inventory, the initial data (available at: http://somci.eng.ua.edu as noted in reference [2]) shows that there are broad categories of misconceptions relating to a “failure to make fundamental differentiations.” It is noted that students often fail to differentiate between normal and shear stress and stresses acting in different directions, however no details are given as to underlying misconceptions and how course materials impact learning. Assessment of how specific course materials impact understanding has been somewhat rare in the literature. However reference [4] and [5] show that interactive courseware can have a marked improvement in the ability of students to generate correct shear-moment diagrams for beams or determine centroids. A survey for faculty on what concepts students have difficulty with is included in reference [6]. Their results were used to inform instructional module development, however details of the results were not provided. Student focus groups have been used to “offer a window on student knowledge” and gauge student’s perspectives on difficult concepts [7] in materials science, but no such data is available for mechanics of materials.

In order to determine why the concept of shear stress is so difficult for students, a student survey and interviews were performed. The survey asks which concepts related to shear stress were most difficult for them, which are easiest for them, what course materials help them learn the concept of shear stress, and to gauge student’s knowledge of shear stress. Interviews were performed to provide additional detail into the student’s responses. From these data, the hypothesis about an underlying difficulty or distribution of difficulties can be investigated. From the survey and interview data discussed below, targeted course materials to correct these misconceptions could be developed and tested, although that is beyond the scope of the work discussed here.

Methods

The mechanics of materials course studied is taught using the following materials and methods.
This course is the first mechanics course that deals with how materials behave and is typically taken sophomore year by Engineering Mechanics, Nuclear Engineering, Mechanical Engineering and Civil & Environmental Engineering students. Three times a week a lecture section of 100 students meets for 50 minutes and is led by a faculty member. A textbook Mechanics of Materials, 4th Edition by Beer, Johnston & DeWolf is required, from which homework is assigned and is used as a reference. A teaching assistant (TA) led discussion session containing 24 students meets for 50 minutes once per week. Schaum’s Outline, Statics & Mechanics of Materials is included with the textbook, but no assignments are from this text. A course website is used to provide internet links to other resources.

In the Spring 2005 semester, the course was team-taught by two faculty members using a mixture of standard lecture and PowerPoint slides. Typically, the PowerPoint slides will have text removed with fill-in-the-blank boxes so that the students remain actively engaged during lecture. A single faculty member taught the Fall 2005 semester. The same textbook, syllabus and class notes were used for both semesters. A student response system, referred to as ‘clickers’, was included in lecture to allow the instructors to ask concept questions in class and get feedback on the level of understanding that the students have. The clickers also serve to encourage attendance by providing identification for participation, which is a graded portion of the course.

The discussion section is lead by a teaching assistant. Most of the discussion time is spent on problem solving. In addition to keeping current with course content, the students are assigned weekly homework and a semester long design project. There are two different types of homework that are assigned: individual problems and team problems. There are approximately six individual problems and three team problems due each week. The design problem is assigned early in the semester with two status reports and a final report due during the year.

Topics that included shear stress were distributed throughout the semester. Shear stress in bolts and inclined planes are covered in the first and second weeks. Torsion is covered in the fourth and fifth weeks. Shear in beam bending is discussed in the seventh and eighth week. The ninth and tenth weeks discuss Mohr's circle.

A nine-question survey was provided to students in an introductory mechanics course in the Spring 2005 and Fall 2005 semesters. This survey was conducted online using SurveyMonkey (www.surveymonkey.com) and took place during the tenth and eleventh weeks of instruction. The text of the survey is included in Appendix A. Formative evaluation of the survey was conducted prior to implementation with students. Several experts in mechanics of materials as well as non-experts outside the field were asked to take the survey and comment on its structure and clarity. The survey was also vetted in a discussion with participants in the Instructional Materials Development course offered by the Delta Program for Teaching and Learning at the University of Wisconsin – Madison. Additionally, three interviews were performed during the thirteenth and fourteenth weeks of the Spring 2005 semester with students in the course who had taken the survey.

Survey results

Responses to five of the questions on the survey are included in this paper. Responses for each question are separated by semester, and the total response is also shown.

Responses to the question, "How well do you feel that you understand the concept of shear stress?" are shown in Figure 1. Nearly 90% of respondents consider it 'easy' or 'very easy' to recognize the term shear stress, recognize equations containing shear stress and use equations containing shear stress. Less than 60% of respondents indicate that they find it 'easy' or 'very easy' to explain the concept to a friend. Most respondents indicated that they were either 'unsure' or would find it 'difficult' to derive equations.

Responses to the questions: "what concept related to shear stress do you have the most difficulty understanding?" and "What concept related to shear stress do you feel that you understand the best?" were quite varied. Each response was placed into topic categories by the authors. The categories and number of responses are shown in table 1 and table 2. While the method of binning is somewhat subjective, most responses could be clearly categorized. In the event that a response fit both categories, it was placed in both categories. Concepts in bold occur on responses from both the concept that respondents have the "most difficulty with" and "understand best".

Table 1 shows responses to the question: “What concept related to shear stress do you have the most difficulty understanding?” As the data indicates, there is not a single topic that dominates. The area or direction of shear stress was the concept cited as most difficult overall, but similar numbers of respondents considered shear in beams and stress transformations to be difficult. Mohr's circle and how to apply knowledge of shear stress were also frequently mentioned.

Table 2 presents responses to the question: “What concept related to shear stress do you feel that you understand the best?” In this case, the application of shear stress is the most frequent response. The definition of shear stress and the concept of double or triple shear in bolts were also ranked high. Torsion and the knowledge that shear was related to load divided by area had different percent of responses each semester, but were concepts that overall were ranked highly.

Responses to “How would you explain the concept of shear stress to another student? Describe in the most detail possible,” were variable and do not lend themselves to quantification. One excellent response reads:

> … One type is normal stress and that involves stress due to tension and compression. Shear stress is different in that it measures the force per unit area that is acting perpendicular to the normal of a surface. In other words, it measures how much force per area is creating a tendency for parallel surfaces to slide relative to one another, not toward or away from one another.

At the other extreme, a response that does not express good understanding:

> … a nail works due to shear stress

Most responses fall between these extremes. Responses that indicated misconceptions about whether the load is perpendicular or parallel to the plane being considered or confusion if the applied force is perpendicular or parallel to the shear stress were often expressed. Respondents also remark that they would need to be able to draw to explain stress. The analogy that shear stress is similar to sliding or friction is also expressed.

Responses to “What parts of the class are useful in helping you understand shear stress?” are shown in Figure 2. Homework is more helpful in comparison to other media. Lecture and discussion section are similar to the homework, with a more people finding lecture ‘moderately helpful’ than ‘slightly helpful’. The textbook is less helpful, but over 50% of the respondents find it ‘moderately’ or ‘very’ helpful. Supplementary materials were considered ‘moderately’ or ‘very’ helpful to around 30% of respondents.

Discussion

Overall the Fall 2005 semester responses were more positive than the Spring 2005. This could be due to a team taught course in spring semester, difference in teaching styles of the faculty, difference in learning styles of the students, timing of the course in the students academic career, or general class makeup; it is not measured by the data.

Responses to the question “How well do you feel that you understand the concept of shear stress?” were similar between semesters. When comparing the near 90% of respondents that could recognize the term shear stress, recognize equations containing shear stress and use equations containing shear stress, the main difference in is in the proportions that indicate if it would be ‘easy’ or ‘very easy’. Fall semester respondents were more confident in how easy they considered each question with the exception of the question on remembering the term shear stress. While it is encouraging that nearly 90% of the respondents are confident in these abilities, they are less confident in their ability to explain the concept of shear stress to a friend. Whether this is due to a lack of understanding or an inability to articulate their understanding is not clear. The fact that most respondents were not confident in their ability to derive equations is not surprising since derivation is not emphasized in the course.

Considering the concept they have the “most difficulty with”, the lack of any specific material indicates that there doesn’t seem to be an underlying cause of difficulty. The fact that Mohr’s circle and stress transformations are highly ranked isn’t too surprising, considering that this survey was given shortly after these topics were introduced and while students were still working with homework on this topic. Shear in beams was also a topic covered recently in the course. The topics of the area or direction of shear stress and how to apply knowledge of shear stress are more fundamental, a lack of knowledge in either of these categories can be problematic.

Respondents’ are a bit more unified in the concept they “understand best”: application of shear stress. However, the responses mainly deal with being able to apply equations after they know that the problem contains shear stress, rather than knowing when the problem requires them to apply the equations, which was the tone of the comments when responses from “most difficulty with” were placed into this category. Double and triple shear in bolts and torsion are examples that include shear stress early in the course, so students have had time to work through problems on this topic. Similarly, the definition of shear stress and that stress is load over area are fundamental concepts that should be understood well.

From this data, there does not seem to be a single underlying cause to the difficulties that students have with shear stress. Since some of the material appears on both the ‘understand best’ and ‘have the most difficulty’ with, peer teaching may be an effective tool to aid students. This statement is supported by the finding that “a given student’s explanation was much clearer to other students” as observed in a focus group setting [7]. Active learning, as implemented in reference [8], has also been shown to improve learning, and prompted further discussion about concept inventories.

Responses to “How would you explain the concept of shear stress to another student?” give excellent insight into the respondents’ understanding. A few offer ideas on demonstrations that could be included in a class:

> … I envision shear as happening between two surfaces such as a board and a desk. If you were to place a board on a desk and apply a small force, friction would keep the board in place until the resistance due to friction is overcome by the applied force. (Maybe that's analagous to the fracture point.) …

The number of respondents who mention that they would need a picture to explain the concept implies that there are a number of visual learners in the class. Also, an analogy to friction is mentioned frequently. It is not clear based on the responses if the respondents understand the distinction between an atomic motion that would imply plasticity and elastic deformation.

Although students complain most about homework, respondents consider homework the most helpful “part of the class”. When comparing the responses between semesters, the proportions for the discussion section are virtually unchanged. One of the teaching assistants involved in the course taught for both semesters, the other teaching assistant position was occupied a different person for each semester. There is a significant amount of variation in how helpful lecture is. This could be due to a team taught course the first semester, difference in teaching styles of the faculty, difference in learning styles of the students, or differences between Fall and Spring student backgrounds, which are not measured by the survey. The textbook was reported to be less helpful than homework, lecture or discussion. The most significant variation in the textbook responses is the amount of respondents who consider it ‘slightly’ or ‘moderately’ helpful. The supplementary materials are rated substantially less helpful than any of the other materials. Unfortunately, the survey does not clearly distinguish what ‘supplementary materials’ mean to the respondents.

Interviews

To further explore some of this data, individual interviews were arranged with some of the respondents. There were 11 students who indicated that they would be willing to participate in individual interviews during spring semester. Of these, 3 interviews were performed. Here are some of their comments.

1. While students recognize that homework is where they learn the best, they do not want any more homework in the class.
2. The different ways of teaching (visual, auditory, kinesthetic) were well represented in the course, but students indicated that they would like more kinesthetic exercises if possible.
3. Students were mixed on the use of ‘clickers’, with cost being the main complaint. However, clickers were defined as being part of lecture, and were not a supplementary material. (This finding was verified in a clicker survey conducted at the end of the spring semester).
4. Students define ‘supplementary materials’ as anything that is not included in

lecture. Additionally those students interviewed admitted they rarely used supplementary materials such as additional websites or references provided. This response is similar to data included in reference [9], which shows a ten-fold increase in use when instructional software is required in the class, rather than only mentioned.

5. Students liked the fact that discussions on shear stress were distributed throughout the class.

While these interviews provide added insight into the students' answers, more interviews would be required to have statistically significant data.

Future Work

Many approaches to helping students understand mechanics of materials topics have been suggested, references [4,5,10-16] are a selection of these. Many of these references discuss using computers or on-line software to provide interactive problems [4,5,10,14] or to aid in visualization [11]. Reference [5] changes the context of homework from "problems" to "games". Other references [11-13,15] make use of physical models that can be integrated into lecture or discussion sections, providing a more kinesthetic example, which may help students with different learning styles. A more comprehensive approach is laid out in references [12] and [16], where an entire course has been redesigned to improve learning.

Creating course material using the methods above to addresses the different shear stress concepts may improve student learning. Unfortunately, many studies do not formally assess student learning and there is no a priori method for determining which of these solutions will work best in a specific setting. Ideally, assessment should be employed when changing course material to see if it actually helps the students learn. An example of this approach has been applied in reference [4] and [5]. The results of this study can also serve as a baseline for future work regarding student understanding of shear stress.

Conclusions

A survey of students in an introductory mechanics of materials course has been performed inquiring about topics relating to shear stress. Most respondents were able to easily recognize and use equations containing shear stress terms, but had more difficulty with explaining the concept to a friend. Responses to which shear stress concept they 'understood best' or 'had the most difficulty with' were quite varied with many concepts appearing on both lists. There does not seem to be a single underlying cause to the difficulties that students have with shear stress. The fact that many responses appear on both lists implies that peer teaching may be effective. Respondents' replies to how they would explain shear stress to another person are varied and offer insight into how students understand shear stress as a whole. Respondents indicate that homework is the most helpful in helping them understand the concept of shear stress, followed closely by discussion section and lecture. The majority of students found supplementary materials, anything that is not included in lecture, to be ‘slightly’ or ‘not’ useful. Additionally those students interviewed admitted they rarely used supplementary materials such as additional websites or references provided.

Acknowledgments
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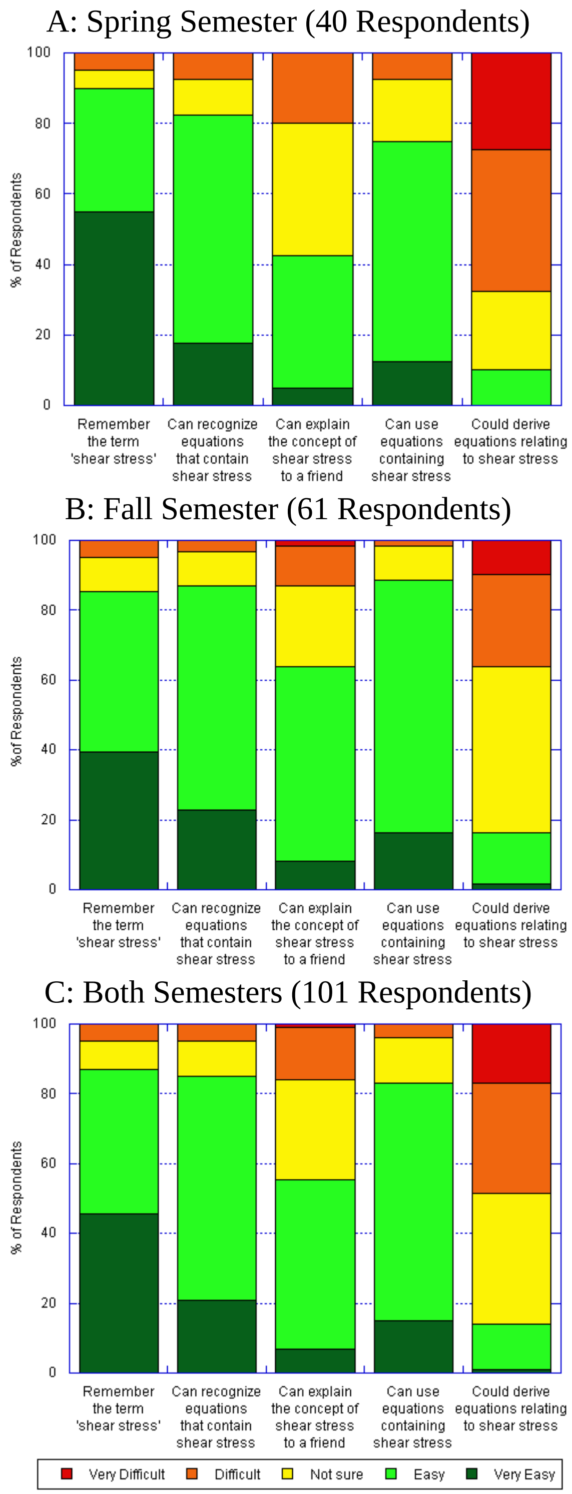
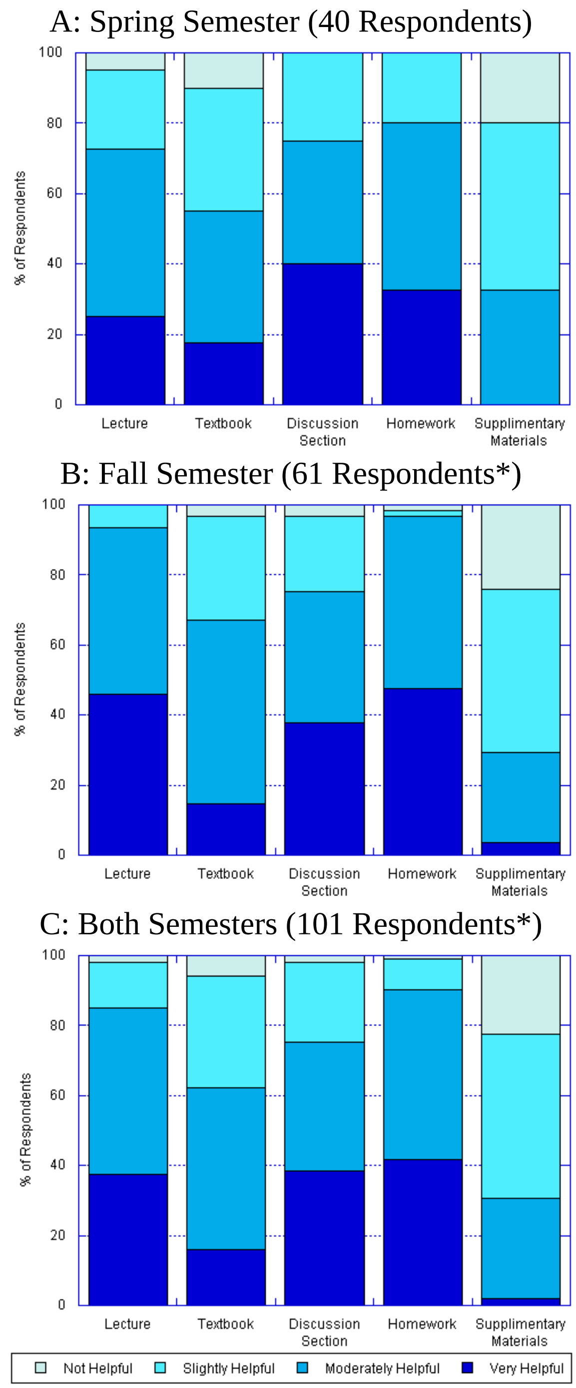


Figure 1: How well do you feel that you understand the concept of shear stress?



* 3 respondents did not indicate a response for the 'supplementary materials" category

Figure 2: What parts of the class are useful in helping you understand shear stress?

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Table 1

Categorized responses to the question: “What concept related to shear stress do you have the most difficulty understanding?” Data is presented as a percentage.
Spring N=40, Fall N=60, All N=100

Concept	Spring	Fall	All
Area or Direction of Shear Stress	12.5	13.3	13.0
Shear in Beams	10.0	13.3	12.0
Stress Transformations (uniaxial)	7.5	15.0	12.0
Mohr's Circle	10.0	8.3	9.0
Application of Shear Stress	7.5	8.3	8.0
Double / Triple Shear (in bolts)	10.0	5.0	7.0
Multiple Equations and Letters	10.0	3.3	6.0
Shear Flow	7.5	5.0	6.0
Advanced Topics	5.0	6.7	6.0
Derivations	5.0	5.0	5.0
Definition of Shear Stress	5.0	3.3	4.0
Visualization	2.5	3.3	3.0
None	0.0	5.0	3.0
Torsion	0.0	3.3	2.0
Internal Stress	5.0	0.0	2.0
Drawing Free Body Diagrams	2.5	1.7	2.0

Table 2

Categorized responses to the question: “What concept related to shear stress do you feel that you understand the best?” Data is presented as a percentage.
Spring N=35, Fall N=58, All N=93

Concept	Spring	Fall	All
Application of Shear Stress	17.1	22.4	20.4
Definition of Shear Stress	11.4	13.8	12.9
Double / Triple shear (in Bolts)	14.3	10.3	11.8
Torsion	8.6	10.3	9.7
Load / Area	17.1	5.2	9.7
Shear in Beams	2.9	10.3	7.5
Area or Direction of Shear Stress	11.4	1.7	5.4
Stress Transformations (uniaxial)	2.9	5.2	4.3
Advanced Topics	5.7	3.4	4.3
Mohr's Circle	2.9	3.4	3.2
Source of Shear Stress	2.9	3.4	3.2
None	0.0	3.4	2.2
Simple Shear	2.9	1.7	2.2
Shear diagrams	0.0	3.4	2.2
Shear Flow	0.0	1.7	1.1

Appendix A

My name is Adam Creuziger, and I am a graduate student in Engineering Mechanics. I am currently taking a course on Instructional Materials Development that is offered through the Delta (www.delta.wisc.edu) Program. The Delta Program is a group of faculty and graduate students who are improving education through research. The primary assignment for this course is to develop materials that will assist students in learning.

I am working on creating materials for EMA 303: Mechanics of Materials that will assist you and future students in understanding the concept of shear stress. I hope by this survey and follow-up interviews to understand what misconceptions or alternative understanding of the material you may have. From this, I will develop course material for future class sessions that will assist students in understanding the concept of shear stress.

Those students who choose to participate in the survey will be given a point of extra credit. Your responses will be confidential. Only a list of students that participated in the survey will be given to the graders, no direct or indirect identifiers concerning your responses will be shared with the graders.

1. Name:

2. E-mail Address:

3. How well do you feel that you understand the concept of shear stress?

	Very Easy	Easy	Not Sure	Difficult	Very Difficult
A)					
B)					
C)					
D)					
E)					

A) Remember the term shear stress
B) Can recognize equations that contain shear stress
C) Can explain the concept of shear stress to a friend
D) Can use equations containing shear stress
E) Could derive equations relating to shear stress

4. What concept related to shear stress do you have the most difficulty understanding?

5. What concept related to shear stress do you feel that you understand the best?

6. How would you explain the concept of shear stress to another student? Describe in the most detail possible.

7. What parts of the class are useful in helping you understand shear stress?

	Very Helpful	Moderately Helpful	Slightly Helpful	Not Helpful
Lecture				
Textbook				
Discussion Section				
Homework				
Supp. Materials				

8. Would you be willing to participate in a focus group to discuss your understanding of shear stress?

Yes No

9. Would you be willing to participate in an individual interview to discuss your understanding of shear stress?

Yes No