



Student Case Study Creation for the Sustainable Side of Material Science

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Dr. Stephanie Luster-Teasley is an associate professor in Civil Engineering and Chemical Engineering at North Carolina A&T State University. She specializes in Environmental Engineering and her research interests include water and wastewater treatment, physical and chemical remediation of soil and groundwater and water sustainability. Her research group has designed remediation system that entails the use of the biodegradable polymers as a mechanism to deliver chemical oxidants to remediate chemical and biological contaminants in wastewater and soil. She conducts educational research where she has creatively works to change educational instruction in laboratory courses by introducing topics in sustainability using case studies. In 2010 she led the NCA&T team that developed the National 4-H Science Youth Day experiment which was used to teach millions of K-8 students about water quality, energy use, and global warming. Her work and research involvement includes over \$2,000,000 of research funding. To date she has received a number of teaching and research awards including the 2005 National Women of Color in Technology Educational Leadership Award, 2006 NCA&T Rookie Researcher of the Year, in 2007 she became the first African American female faculty member to achieve patent pending status at A&T for her technology invention, in 2008 she received the NCA&T Junior Teaching Faculty of the Year Award, and in 2010 became a Department of Homeland Security Summer Research Fellow, and most recently in 2011 was named one of the 40 leaders under 40 by the Triad Business Journal.

Student Case Study Creation for the Sustainable Side of Material Science

Abstract:

Case studies have long been used in law and in medical education and are essentially a form of storytelling with an educational message. The case is an account of an activity, event or problem that contains a real or imaginary situation and incorporates the intricacies you may encounter in the real world. Engineering faculty have begun looking towards these methods as a powerful pedagogical technique for teaching. Recent NSF funding on a TUES Type 2 is allowing the authors to create cases with a focus on sustainability. Why sustainability one may ask, “The shift to more sustainable technologies will mean significantly reducing the amount of energy and materials we use in producing our goods and services while decreasing risks to humans and the environment” (Bridge to a Sustainable Future, Clinton, White House, 2005). Many of the best cases are based on contemporary, and often controversial, science problems that students encounter in the news; the use of cases in the classroom makes science relevant and research shows that relevance promotes learning. Constructivism adopts the belief that students learn most effectively by constructing their own knowledge and refer to learning as conceptual change (Vygotsky, 1962; von Glasersfeld, 1987, 1995). That being said the present work utilizes undergraduate students working on consultant teams to create the cases as a part of their Honors Contract. XXX University has a system in place for Honors students to gain honors credit for courses in agreement with the instructor. The National Center for Case Study Teaching in Science at the University at Buffalo is utilized as a primary resource and its purpose is to “promote the development and dissemination of materials and practices for case teaching in the sciences.” The paper will first discuss the use of an Honors contract to facilitate creation of cases, then a discussion of case study theory, a sharing of the cases created by the students and finally reflections of the students and faculty.

Honors Contracts:

The mission of the program is to develop well-rounded scholars and leaders who are culturally, intellectually, and globally minded. “The Honors Program is for highly motivated students filled with ideas, gifted with creative expression, and enthusiastically ready for career shaping challenges, the University Honors Program can meet their needs. Students enjoy an array of academic enrichment and co-curricular experiences that will prepare them for life beyond the baccalaureate.” As few Honors courses are offer the students have the opportunity to earn honors credits for other select courses through a student faculty created contract. The section describing the activity is displayed below; see the appendix for a complete contract.

Description of the Contract Project or Activity

After consulting with the instructor, the Honors student must indicate below the additional work and/or activities that will be completed in order to earn Honors credit for this course. Also indicate the timetable agreed upon, including the final due date. The Honors student must obtain the instructor’s signature on the front page and, then, bring the signed form to the Office of the Honors Program in 117 New Academic Classroom Building.

Prior to the start each semester students meet with chosen faculty in their courses to discuss ideas for a curricular opportunity. These have in the past included research papers with presentations

to the class and the current work had the three students working on a consultant team which met together bi-weekly with the faculty to read past cases, to brainstorm, and to then write their individual case study and finally they reviewed each other's work.

Case studies:

This educational effort was initiated to enhance student critical thinking and analytical skills in a Introduction to Materials Science course. Research has shown that use of interactive, inquiry-based instructional methods in classes is more effective for increasing students' critical thinking skills, retention of material, and learning concepts (Benbasat, Goldstein et al. 1987, Herreid 1994, Abraham, Craolice et al. 1997, Herreid 2004). Therefore the educational intervention entailed forming a student team to study and then create modules which use case studies, problem-based learning, and guided-inquiry to introduce materials related topics. In a true case study pedagogy students are provided with a problem and they discuss, research, and work as groups to solve the problem. The learning is self guided and contextual in nature. Therefore, these methods are student focused and student-guided to help promote active instead of passive learning (Benbasat, Goldstein et al. 1987, Lee 1989, Herreid 1994, Herreid 1997, Herreid 2004, Yadav, Lundeberg et al. 2007).

Based on research in the literature the students were directed to the National Center for Case Study Teaching in Science (NCCSTS) website, (<http://sciencecases.lib.buffalo.edu/cs/>) to begin their process. They were specifically asked to read "Baffled by the Baby Bottle"⁸, see Figure 1 for a sample of the student content. This case refers to another article "Baby Alert" which appeared in *Consumer Reports* (May 1999). The article raised concerns about the safety of polycarbonate baby bottles, and recommends that parents dispose of them as a precaution.

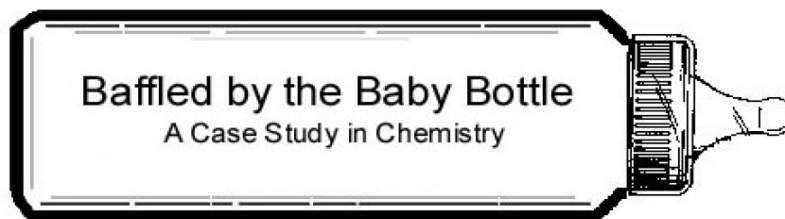
Additionally, for the current work the authors experience in developing case studies developed the following loose guidelines to give the students:

1. tell a story that has a beginning, background, a middle, and a conclusion.
2. trigger your peers interest.
3. have real characters to identify so that the student can role play one of those characters. It helps bring out the subjectivity of decisions and how credibility of a person influences decisions.
4. bring out the real-world issues. Videos, photographs, and multi-media technologies need to be utilized so that the students can get a good understanding of the technologies involved in each case study.

Implementation:

The undergraduate students working on consultant teams will henceforth be called the "case study group" conducted their research on the topic by working outside of class in teams to read the sample cases and reflect on their preference and the case differences. The case study group was asked to identify what they know and what they would need to know to solve each case from the samples. The pedagogy for class implementation is to have students read the case and then identify what they need to know, conduct research for the assignment and develop a solution which is presented in the group project report and presentation.

The case study group started with three students who self selected to complete an Honors contract with the Intro to Materials Science course. The timeline is shown in Table 1.



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"Wow, I can't believe baby Maggie is already two weeks old!" exclaimed Bob.

"I know; I'm so glad you could get time off work to come here to the doctor for her checkup," replied Bob's wife, Julia. "How are things going at BB Plastics?"

Bob's answer was interrupted by Maggie as she started to fuss in the waiting room. Bob promptly got out the bottle of formula and started feeding Maggie.

"Bob, what are these bottles made from?" Julia inquired. Julia had recently read an article in a magazine which discussed possible health problems for babies fed with plastic bottles.

Figure 1. A portion of the student version of the Baffled by the Baby Bottle from the NCCSTS website.⁸

Date	Topic	Action item after meeting
September 7th	Initial group meeting	Read sample case studies
September 21st	Group Meeting	Discuss sample cases
October 1st	Group Meeting	Presented ideas for individual case study
October 8st-October 15th	Individual meetings with Faculty	Discussed details of the idea and got feedback from faculty
November 2nd	Group Meeting	Present completed cases to the group, then each member was to provide written feedback to each other.
November 14th	Group Meeting	Final modified case study presented.

Table 1: Timeline for case study group work.

The students struggled with coming up with a viable idea that related to Material Science and sustainability. After the Oct. 1st meeting they were referred the group to read Chen et.al's paper on , "Infusing the Materials Engineering Curriculum with Sustainability Principles"⁹. This paper discusses that in order to adequately present sustainability principles, students must first be made aware of current global challenges. Some of the issues included climate change, rising gas prices, and poverty. This reading helped spark more ideas

We Completed cases were as follows:

Case study 1: *The Recall*

Early in the bright morning in 2010, Marcus was up thinking about buying his first car. Every car a person could think of was running through his head from a Mercedes-Benz to a Nissan Altima. While Marcus was thinking about which car he really wanted, he had to put everything into perspective. Marcus is a new employee at a big time company which he is not allowed to reveal, he is twenty-four and just graduated from graduate school with his Master's Degree in Business two months ago. Now he has entered the real world where the bill collectors start calling every day and night about the cell phone bill, student loans, and other bills. With these extra responsibilities on his back he has to manage his own budget the right way therefore, when looking for a car he has to find something that can fit his style and budget.

****Complete case found in the Appendix*



Case study 2: *Fore*

Nice breeze, beautiful water, and family. My family and I are on our annual vacation. This year my parents decided to take my sister and I on a cruise. My sister and I have never been on a cruise before so we felt this would be exciting. So here we are standing on the deck with our flip flops on and our Hawaiian shirts blowing in the wind smelling like sun screen trying to decide what our next activity should be. My father suggested that he and I should go golfing, it sounded fun I have never been golfing before so off we went, while my sister and mother went and did some different events.



Reflection:

Feedback from the small case study pilot group suggests they felt the case studies that they created were more engaging compared to what they might do in their traditional lecture classes. The cases that were completed were chosen by the students, therefore were interesting to the students. That is the first crucial step to more effective student learning. The students particularly enjoyed the real world approaches and seeing how they could expect to apply their topical knowledge to their real jobs after graduation.

Herreid 2004 states it well when he says:

William Perry, the Harvard psychologist famous for outlining the Perry model of student development, pointed out that the earliest stage in the maturity of students is the “dualist.” The dualist student sees the teacher and parents as absolute authority figures and everything in the textbook as correct. There are always right and wrong answers to questions. The job for these students is to learn that what teachers say is truth and regurgitate it back on the tests. The trouble with the lecture method is that it perpetuates this stage in students. Further, it distorts the actual way that science is accomplished. Students are left with the idea that Newton, sitting under an apple tree, was bonked on the head and gravity was born—it was all “eureka!” Case studies don’t do this. They show the messy, get-the-hands-dirty approach that is the real science. Cases demand skepticism, flexibility, and the ability to see alternative approaches. Problem solving is its sine qua non. In short, cases demand critical thinking.

The initial feedback shows that students would like more details on expectations e.g. level of independent research needed. We found that much of the case studies research was derived exclusively from the Internet. This is a valuable resource but in order to expand the potential for learning the question generation in each case of significant in student learning. Another method to expand student learning was the critical analysis of each other’s work. The response has been very positive. Students generally have an interest in making a difference in the world, and they are motivated by the thought that their knowledge and skills could be helpful to others

Conclusion:

There is a need to better prepare engineering students for the challenges and complexities of today’s environmental issues. The challenge is how to fit the experience into a jam-packed curriculum. The Honors Contract is an excellent tool for this case study creation. The quality of work can be varied and not all students will complete the task as only two out of the three students completed a case for review. More work is needed to create a greater bank of case studies for the Material Science curriculum and when complete all are encouraged to upload into the National Center for Case Study Teaching in Science (NCCSTS) website, (<http://sciencecases.lib.buffalo.edu/cs/>).

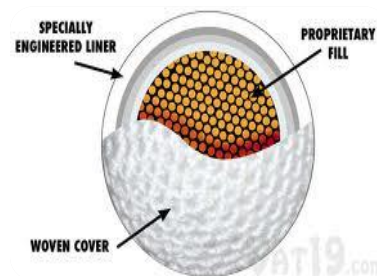
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Appendix:

Case study 1:

Fore!



Nice breeze, beautiful water, and family. My family and I are on our annual vacation. This year my parents decided to take my sister and I on a cruise. My sister and I have never been on a cruise before so we felt this would be exciting. So here we are standing on the deck with our flip flops on and our Hawaiian shirts blowing in the wind smelling like sun screen trying to decide what our next activity should be. My father suggested that he and I should go golfing, it sounded fun I have never been golfing before so off we went, while my sister and mother went and did some different events.

So my father and I set off to try out our golfing skills. When we arrived at the golfing section I thought there would be holes that we were aiming for like mini golf or something but people were just hitting the balls in to the ocean. I didn't see the fun in it, it did not seem like

there was a point, but then I saw the joy on some of the people's faces when they hit the golf ball hundreds of feet away from the ship soaring into the water. Seeing that it could potentially be fun I was eager to try my hand at it, but I did not know how to swing the golf club properly. My father was an expert he took the golf club and got in his golfers stance and swung club and the golf ball went flying into the water with a huge ark and a splash. He said, "And that's how it's done son."

He then showed me how to properly stand and swing the golf club I had some success but the ball was not going nearly as far as his was. As soon as I started really enjoying myself a woman came over and yelled, "Stop what you are doing." Everyone paused and looked at her as if she was crazy. She then said, "You all are murderers." I thought to myself, "me, a murderer?" Though I knew I didn't do anything wrong or at least I didn't think I did anything wrong I began to feel guilty because the tone in her voice sounded so compelling and serious. She then said "do you know each ball you hit in the water could potentially kill an animal in the ocean." We all looked at each other in confusion. How could a small ball kill an animal in the ocean? She then said, "Thousands of animals come across your golf balls and mistake them for food and attempt to eat them and choke to death, and those that are able to swallow them can have issues in their digestive track because they are unable to digest them and the ball clogs their intestines and also leads to death." I looked at everyone's faces, some people are looking like, this woman is crazy but some seemed genuinely upset and concerned. She paused for a moment to let it all soak in then she exclaimed, "wait! There's more, also the material that the golf balls are made out of takes a long time to break down so the ball sits in water for a very long time, but when they do eventually start to break down the chemicals that make up the ball seep into the water making the nearby water toxic to the animals nearby, this is not only limited to the ocean but also back on the inland in your lakes and ponds as well."

Another woman interrupted and said, "Oh my goodness I never knew this activity that is fun for us, could cause so much harm, is there anything that can be done?" The women replied, "Yes there are golf balls that are completely safe to use." A man asked, "How are they different from other golf balls." She then replied, "The new golf balls are completely water soluble and biodegradable, and when they do break down they are nontoxic." Everyone then looked at each other in agreement that these new golf balls sounded much better. The women then said softly, "Thank you for listening I hope you all will have a different outlook on your activity and how it can be dangerous." We looked puzzled not knowing what to do now because no one felt comfortable taking another swing so we all just watched as she walked away.

Questions

1. Read the Heavy Metals Found section of the golf ball article and state some of the reasons normal golf balls are a hazard to the environment?
2. What was the solution to the issues that the normal golf balls cause?

3. What makes the new eco golf ball better for the environment?
4. Name the polymers used to make the eco golf ball that allow it to behave the way it does. What is the polymer that makes up the majority of the golf ball and what is its exact percentage?
5. Name some of the safety hazard for PVA.
6. Read section 10 and 11 of the material safety data sheet for the eco golf ball, does the golf ball seem safe for the environment and animals?
7. Read section 5 of the material safety data sheet for PVA does it seem relatively safe to work with?

Links for Questions

MATERIAL SAFETY DATA SHEET FOR ECO GOLF BALL

<http://ecogolfballs.com/images/specs.doc>

MATERIAL SAFETY DATA SHEET FOR PVA

<http://www.ayersintl.com/wp-content/uploads/2011/08/MSDS-polyvinyl-alcohol.pdf>

INFORMATION ON REGULAR GOLF BALLS (ARTICLE)

<http://suite101.com/article/litter-on-the-links-problem-grows-a168423>

Case study 2:

The Recall

By,

Randall T. Fields

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Early in the bright morning in 2010, Marcus was up thinking about buying his first car. Every car a person could think of was running through his head from a Mercedes-Benz to a Nissan Altima. While Marcus was thinking about which car he really wanted, he had to put everything into perspective. Marcus is a new employee at a big time company which he is not allowed to reveal, he is twenty-four and just graduated from graduate school with his Master's Degree in Business two months ago. Now he has entered the real world where the bill collectors start calling every day and night about the cell phone bill, student loans, and other bills. With these extra responsibilities on his back he has to manage his own budget the right way therefore, when looking for a car he has to find something that can fit his style and budget.

As days and weeks have gone by and much research has been done by going on different car websites to figure out which car fits him best. While trying to discover what car company provides the best safety features and prices on cars Marcus now decides that he has done his research he need to start visiting different car lots and talking to the dealers about what car best fits him. As more days have passed Marcus has been talking to all the types of car dealers and decides to take a trip to Toyota and talk to them about their 2010 Toyota Camry, once they started engaging in talk about the Camry Marcus was becoming particularly more interested in the car. As the conversations continue to progress prices and deals were being thrown out on the Toyota Camry and after they had finish talking Marcus was convinced that the Camry was meant for him. After leaving the dealership and heading home he was thinking about whether he should get the Camry or not. When he woke up that next morning Marcus had his mind made up that his first owned car was going to be the Toyota Camry. That same day Marcus went to the dealership and put the down payment on his new Toyota Camry.

Now on the road feeling like a free man with his own car he does not have to depend on any other transportation except for his own vehicle. Now that Marcus is driving he can tell how smooth his car drives with no problem. Driving his car from sunrise to sunset, Marcus was having a blast being able to drive himself to and from work and anywhere else he pleased. As weeks and months started going by his car started leaking brake fluid because of defects in his brake master cylinder, but Marcus never knew it because his car has yet to give him any problems during his drives on the road or highway. So he kept driving his car without knowing to let anyone look at it to see if there was anything wrong with the Camry. One day while driving his Camry Marcus was flying up the highway trying to get to work on time. While driving as fast as he was a red light came up, so he try to slow down for the red light that was approaching and Marcus noticed that his car was not slowing down for him to stop at the light. Marcus started panicking while in the car but luckily the light switched to green as the car reached the light but there still was a problem because the brakes still were not working while he was driving to work, while in the car thinking of what could do to stop his car and save his life Marcus started to pump his brakes constantly to see if he could get any control back over the car. As Marcus came upon a sharp curve still without any brakes he just knew that this was the end of his life approaching but a miracle happened and Marcus' brakes came back into commission to save his life while going around the curve. Once he got around the curve he pulled to the side of the road and put his car in park and just sat there with the adrenaline still running through his body.

Once calmed down in the car Marcus turned on the radio to listen to the news while he got ready to call his boss and tell him about what just happened to him with his car and notify him that he will be late for work. While on the phone with his boss, Marcus heard something on

the radio that was talking about how Toyota is having a recall on most of their vehicles because of their braking systems with all the bad accidents that were going on with some of their cars brakes going out on the drivers. Once Marcus heard what the news said and ended his phone conversation with his boss. He caught the bus to work and called Toyota once he got to his desk to tell them about his accident and let them know where his car was park so they can take it back to the manufacturer after the morning incident and hearing about the recall on Toyota cars.

Part I: Background

The Toyota Motor Company announced a global recall of 1.53 million vehicles on Thursday because of brake and fuel pump problems, but stressed that the repairs reflected a companywide effort to be more active in addressing potential flaws.

Toyota, the world's largest automaker, will call back about 750,000 cars in North America, including Lexus and Avalon models, and 599,000 cars in Japan. The recalled models were mostly made from 2004 to 2006; a period of rapid growth for Toyota that analysts have charged coincided with lapses in the automaker's attention to quality.

About 140,000 cars in the rest of Asia and Australia, and 50,000 cars in Europe, also are being recalled.

Most of the vehicles in Thursday's recall need to be fixed for a problem in the brakes' master cylinder, Mr. Nolasco said. The cylinder, which contains brake fluid, could leak if filled with a third-party fluid, causing a loss in braking power, he said.

Question

1. What caused Toyota to have recall?
2. How many vehicles were called back around the world?
3. What between which models years had the most recall?



Part II: Brake Master Cylinder

The brake master cylinder is attached to the brake booster and is allows the driver to apply pressure thru the master cylinder to the braking hydraulic system. The brake master cylinder will have a plastic brake fluid reservoir attached to the top of the unit.

Your master cylinder is an important component of the overall brake system, which works to slow and stop your car or truck. The master cylinder includes pistons, springs and two compartments that hold brake fluid. It is important to have a properly functioning master cylinder since a failing master cylinder will likely cause the brakes to not work. You picked a performance-optimized car to take advantage of its excellent power and performance, protect your decision by installing first rate aftermarket parts.

Question



1. What is attached on the top of the Brake Masters Cylinder?
2. How often should you flushed out you brake fluid in a Brake Master?
3. What does the Master Cylinder contain?



Part III: Recycle Brake Fluid

To recycle brake fluid, recyclers will most likely mix it with other fluids to create alternative fuels which are then uses in other applications. So when you're stuck with used brake fluid and in need of a recycling solution, there are several things you can do. But first, prepare it for transportation to the recycling center by sealing it in a jar with a secure lid. Then try out these recycling options: **HHW collection, Your local auto shop, and Landfill options.**

Question

1. What chemical component makes up brake fluid?
2. Where can you recycle brake fluid?
3. What the most common braking system failure?

Part IV: Reduce Brake Fluid Waste

As with most recycling issues, pre-recycling is the best way to minimize the amount of recycling you have to do, and brake fluid is no different. To cut the amount of brake fluid disposal work you have to do: **Limit quantities, Change when necessary, Reuse, and Don't mix.**

1. What ways our there to clean or strip fluid?
2. Can you over use brake fluid?
3. Can brake fluid be mix?



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