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YouTube Fridays: Student led development of engineering estimate problems

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ABSTRACT

YouTube Fridays devotes a small fraction of class time to student-selected videos related to the course topic, e.g., thermodynamics. The students then write and solve a homework-like problem based on the events in the video. Three recent pilots involving over 300 students have developed a database of videos and questions that reinforce important class concepts like energy balances and phase behavior. A set of example problems and videos are presented from a sophomore level engineering thermodynamics course and a sophomore level material and energy balances course. Student evaluations found a vast majority (79%) of the students felt better at relating real world phenomena to thermodynamics from participating in YouTube Fridays. Overall, YouTube Fridays is a student led activity that provides practice of problem solving on open-ended, course related questions.

Keywords: Technology in the classroom, YouTube

INTRODUCTION

Today, most students enrolled in higher education were born in the 1980s or 1990s and have grown up with access to computers, the Internet and many other electronics for daily use. The men and women who make up this demographic are designated as digital natives or the Net Generation. Numerous studies on the positives and negatives of the technology savvy students in education

and the work force have been published [1-6]. Here, a simple use of technology, specifically videos from YouTube, can be used to engage this generation of students and be a source of new course material.

YouTube Fridays (YTF) began as a way to encourage attendance at 8 am on Friday mornings during the Fall 2008 semester. The first five minutes of class was dedicated to videos related to the professor's research at the beginning of the semester and the course, namely thermodynamics, for the remainder of the semester. The videos were student selected by groups of 3 or 4 students. After showing the videos, a short discussion on the videos relationship to the course topics followed. The first two pilot studies of YouTube Fridays were published [7] and provide the starting point for developing new course problems from the videos (the topic of this paper). Overall, YouTube Fridays provides one active learning strategy [8] to engage the digital natives in higher education.

Each homework assignment in the Introduction to Engineering Thermodynamics class at the Colorado School of Mines includes an "Engineering Estimate" or EE problem. These are open-ended problems where most, if not all, of the data needed must be estimated in order to arrive at a reasonable solution. Initially introduced in the fall of 2003, many problems are cast to show if something is possible or if it is fraudulent or infeasible. EE problems are an easy way to include problems dealing with energy and the environment into the class. For example, one EE problem asks if the government claim that increasing the gas mileage from 20 mpg to 25 mpg will result in reducing the carbon dioxide added to the atmosphere by 10 ton/year for each vehicle (This estimate is reasonable).

Here, YouTube videos selected by the students have been successfully used as a basis for EE problems and for active classroom discussion. Implementation of YouTube Fridays and a select group of example problems derived from the videos are presented first. Evaluations of this teaching technique, including student comments, and concluding remarks complete this work.

IMPLEMENTATION

YouTube Fridays was piloted primarily as part of two courses over the last two academic years (Table 1). Introduction to Engineering Thermodynamics, a sophomore-level class for chemical engineering, engineering physics and civil engineering students, primarily covers the 1st and 2nd laws of thermodynamics (i.e., energy and entropy balances). Material and Energy Balances is a sophomore-level course for chemical engineering students and the first chemical engineering course in the curriculum. The student-selected videos were required to relate to the topic of the course (either thermodynamics or material and energy balances), and write and solve one engineering estimate problem based on the video. Highlights from the over 70 videos provided "new" course content

Pilot	Course (n=number of enrolled students)	Semester	Student Selected Videos	EE Problem	University Course Evaluation	YouTube Specific Evaluation
1	Introduction to Engineering Thermodynamics (n=40)	Fall 2008	Yes	No	Yes	No
2	Material and Energy Balances (n=55)	Spring 2009	Yes	No	Yes	Yes
3	Introduction to Engineering Thermodynamics (three sections, n=85, 55, 55)	Fall 2009	Yes	Yes	Yes	Yes
4	Introduction to Engineering Thermodynamics (n=88)	Spring 2010	Yes	Yes	Yes	Yes
5	Material and Energy Balances (n=57)	Spring 2010	Yes	Yes	Yes	Yes

Note: Pilots 1 and 2 were detailed in an earlier publication.

Table 1: Outline of the two pilots of YouTube Fridays.

and reinforced the primary learning objectives of the courses. The complete list of videos to date are available online [9] and in the Appendix.

For every pilot, the students were divided into groups of 3 to 5 students to complete the YTF assignment one time over the course of a semester. Group assignments have been made on a random basis or by letting the students self-select their group. The type of group assignment did not lead to differences in the quality of the EE problems (based on grades earned on the assignment). Based on comments from the first two pilot courses, the most recent YTF assignments have included a peer evaluation. To ensure all members of the group were contributing, a peer evaluation is required for each student to grade all of the members of the group (implemented for pilots 3, 4, and 5). A 5-point scale was used for the peer evaluation, and any student receiving an average score less than three would receive no credit for the YTF assignment. The peer evaluation results were almost always digital, i.e., scores of 5 or 0. Either groups worked well together gave each other perfect scores or students didn't participate in the group and they received zero on the peer evaluation.

At the start of the semester for Pilot 4, videos and EE problems from previous semesters demonstrated the type of problem statement and solution required. In this case, the video was shown (several times if necessary), the problem posted, and groups of students are given a limited amount of time work to develop solutions. Solutions from several different groups, selected so all groups will be called on during the semester, are then posted to the board for discussion. Typical questions posed to start the active involvement of the students are things like "what thermodynamic concept

is illustrated here", "what is the mass of the …", "how fast do you think …", "draw the process path on a P-T diagram", etc. For example, the sledding failure video [10] was shown and students are asked, from a conservation of energy analysis, to estimate the velocity of the sled-rider immediately before impact with the car and the total kinetic energy transferred to the vehicle.

Pilots 3 and 4: Engineering Estimates for Engineering Thermodynamics

Concepts covered in Introduction to Engineering Thermodynamics include unit conversions, reading steam tables and phase diagrams, energy conservation, and entropy. The myriad of videos selected over pilots 3 or 4 encompasses most of the content in the course. The unrestricted, student led nature of the assignment led to many videos related to phase changes, reactions, and explosions. Specific examples, detailed below, summarized the relationship between thermodynamics (sometimes viewed as an abstract and conceptual subject) and the physical world around them.

A couple of EE problems written by students mimicked recent problems from class. One video showed a wind turbine spinning out of control and being destroyed [11]. The students wrote a problem with the same basis as a recent homework problem. The student's examined how much kinetic energy and power would be produced from hurricane force winds (100 mph) right before the windmill was destroyed. The students estimated a mass flow rate of air from the density of air at the assumed temperature, area of the wind turbine and wind velocity. The result was 500 times the kinetic energy as the previous homework problem. The students concluded that while a lot of energy can be obtained in a hurricane, the destruction of the windmills is why windmills are not built in climates where hurricanes are common.

Unit conversions, energy balances and some critical thinking were obvious in many of the EE problems. For example, a lance made out of bacon was used to cut steel in one video [12]. The EE problem found the fraction of the energy (efficiency) in the fat of the bacon needed to melt a small area of a steel sheet (Figure 1). The result of only needs a little more than 1% of the energy makes this experiment seem very reasonable.

In another video [13], the dangers of everyday items helped students understand why water heaters have pressure relief valves. Turning a hot water heater into a rocket simply required the pressure to build up inside the water heater. One group estimated the initial acceleration of a water heater rocket and found 1300 m/s^2. (Consider a Porsche's acceleration is about 7 m/s^2.)

The simple boiling and freezing of water is one phase change studied over the course of the semester. One video [14] duplicated an experiment conducted by Dr. William Cullen in Scotland in 1775. A beaker of water is placed in a vacuum chamber, the pressure is reduced and the

Question

Estimate the minimum percentage of energy stored in the bacon that was used to melt the hole in the steel plate.

Solution

Known: 7 Pieces of bacon used, Pure oxygen used to propel flames.
Find: Minimum amount of energy required to melt the hole in the steel plate.
Assume:

- Steel plate:
  - 4mm Thick, area is ~44.18cm^2
  - Melts at 1,370 °C, Specific Heat: 500 J/kg*°C, Density: 7,850 kg/m^3
- Bacon:
  - 1 slice = 1 serving = 1 oz., 1051 kJ (from fat) per serving

Analysis

V=A*h = 44.18 cm^2 * (1 m^2/(100cm^2) * 4mm * (1m/1000mm) = 1.77E-5 m^3

(.5 kJ/kg*°C)*(7,850 kg/m^3)*(1.77E-5 m^3)*(1,370°C) = 95.1773 kJ required to melt through that amount of steel.

7 slices (1 oz/slice)*(.0283kg/oz)*(1051kJ/.0283kg) = 7357 kJ produced by 7 slices of bacon.

(95.1773kJ/7357kJ) * 100% = 1.2937% of the energy from bacon is needed.

Figure 1. Students' engineering estimate problem about a torch made of bacon.

water actually boils and then freezes. The students' EE problem asked to draw a pressure versus temperature diagram and determine the change in enthalpy for this process (Figure 2). Both parts of the students' problem would be fair to ask on a quiz or exam for the course.

Determining fact or fiction has become a common theme of YouTube Fridays and the accompanying EE problems. In one video titled the Big Water Slide + Jump! [15], an individual slides down a slip-n-slide ramp, flies through the air, and lands in a kiddie swimming pool. The EE problem posed by the students was is this feasible based on conservation of energy principles (potential and kinetic energy). Based on the assumptions the team members made (mass of the individual, height of the slide, angle of the ramp), they used a projectile distance traveled analysis (obtained from Wikipedia) to calculate the distance the individual would travel. They concluded that it was a fraud.

After the semester ended, one of the authors received an email from a student in the class showing the Mythbusters attempt to experimentally prove or disprove the YouTube video [16]. A comparable slide was built and tested by the Mythbusters. The YouTube video was determined to be fake based on the very short distance that a person flew after using the recreated slide. Overall,

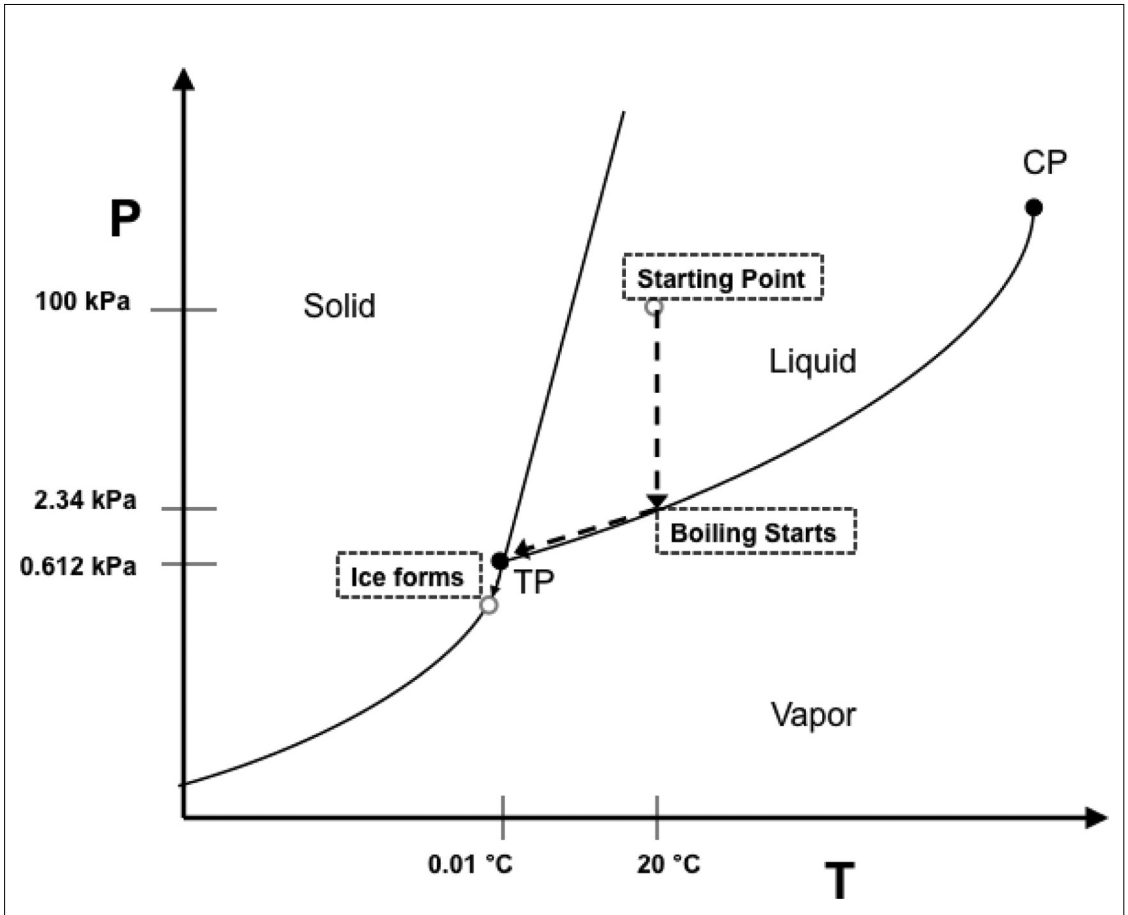

Figure 2. Students' engineering estimate problem about a torch made of bacon.

determining fact or fiction from YouTube videos showed the development of problem solving and critical thinking skills that the students used even after the semester ends.

The Big Water Slide + Jump! video was given to the Fall 2010 Introduction to Thermodynamics class as a EE problem on the first homework assignment. Every student claimed the video was a fraud. Most calculated the distance traveled but a few students used time of flight of a projectile to arrive at their conclusion. Several sharp eyed students pointed out that the individual suddenly is wearing a pair of skis as he is flying through the air and he didn't have them on when he started at the top of the slide. The attention to detail shown by the students will serve them well in their course and future engineering jobs.

Overall, solving problems involving energy balances is a main objective of the course. Many more videos exemplify this topic including the ability to lift a car off the ground using only fire hoses, which are detailed in the Appendix.

Pilot 5: Engineering Estimates and Material and Energy Balances

The chemical engineering curriculum traditionally begins with a course in material and energy balances, as it does at the Colorado School of Mines. The majority of the students (~75%) have already completed the Introduction to Engineering Thermodynamics course discussed previously while the rest are taking thermodynamics co-currently with material and energy balances. The strong emphasis on energy balances in the thermodynamics course and related videos was demonstrated above and will not be repeated here. The material and energy balances course can be categorized as a "comprehension" course. The students must learn to read problem statements, construct a picture of the system, and logically solve the problem.

Three videos and their accompanying problems showed that YTF reinforced the primary objectives of the course. The drawing and labeling of a process flow diagram (PFD) is a necessary skill to moving on to the junior year in chemical engineering. Turning text into the PFD is the first step to problem solving almost all problems in this course. Converting the videos to a PFD was clearly and correctly completed by nearly all of the groups. For example, one video talked about providing the world's fuel by growing algae [17]. The EE problem simplified the process to a single reactor with algae as one inlet stream and "heavy" algae as one outlet stream (Figure 3a). Another group developed an EE to mimic a recent course problem related to chipping and drying wood [18]. Their EE problem covered concepts like relative humidity and gauge pressure in addition to material balances. Finally, a video titled "how condoms are made" described this chemical production process in detail [19]. The group used the video's description to reconstruct a multi-unit PFD (Figure 3b). This PFD quite accurately represented the production process described in the video including the production rate of the product.

Overall, extracting a PFD from a video demonstrated the connection between physical processes and the course content. An additional set of videos during Pilot 5 centered on the profession of chemical engineering with similar videos and analysis were included in an earlier publication [7].

Evaluation

Students completed evaluations during class near the end of the term. A combination of multiple choice questions and free response allowed the positives and negatives related to the YouTube Friday assignment and creating EE problems to be cataloged (Table 2). Since the focus in pilots 3 and 4 (thermodynamics) was creating new EE problems related to the course, student feedback on their comfort with open-ended problems was solicited. While a majority felt they had a better understanding of the course topic of thermodynamics (63% strongly agree/agree), a larger majority could relate thermodynamics to real world phenomena and feel confident solving engineering estimate problems (79% and 69% strongly agree/agree, respectively). The reinforcement of concepts

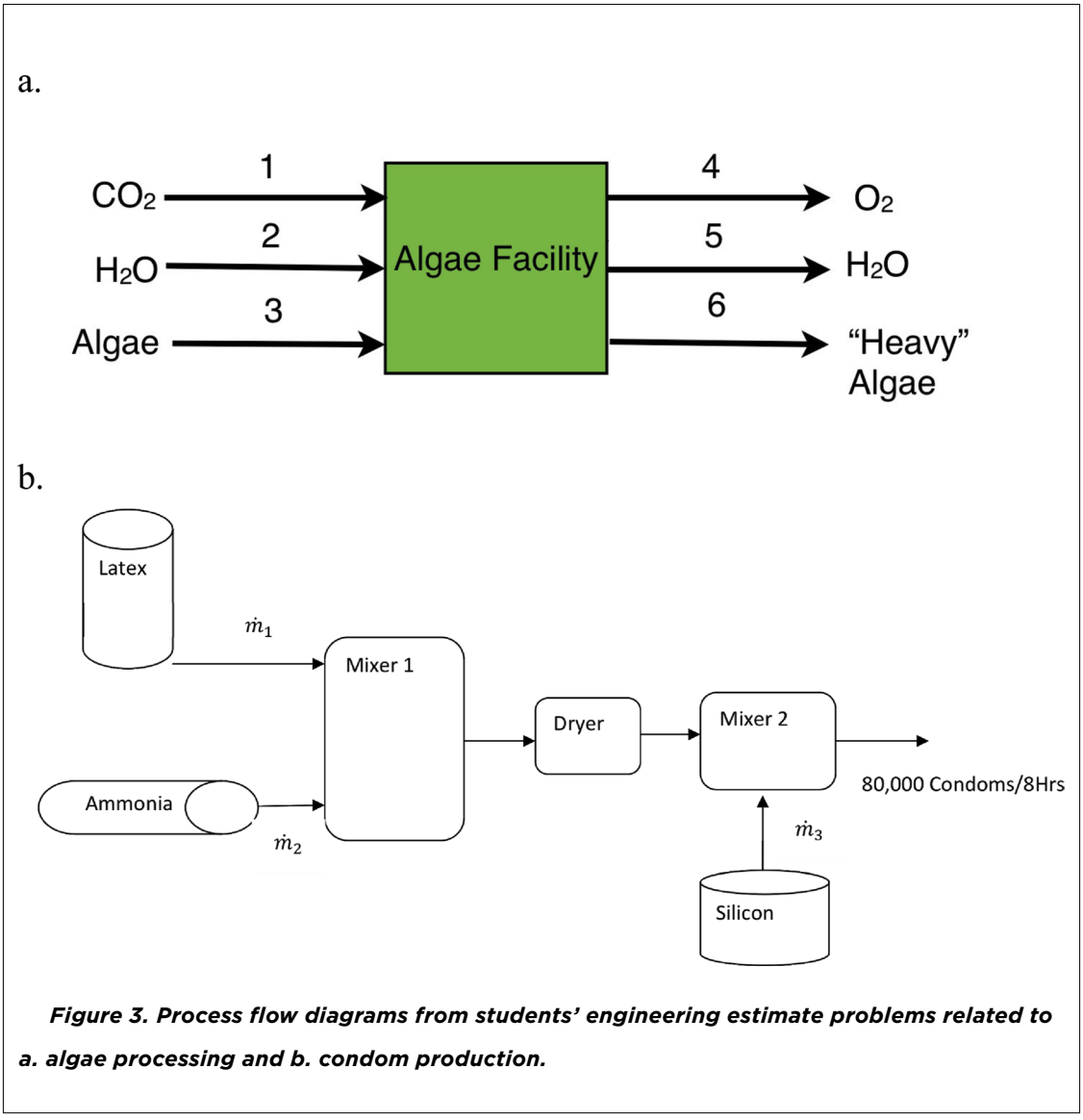

Figure 3. Process flow diagrams from students' engineering estimate problems related to a. algae processing and b. condom production.

in the course and a fun, student led activity like YouTube Fridays was valuable to the students' engagement and learning. In addition, over 40% of the class thought YouTube Fridays helped them learn the course material. Tying together concepts from videos and open ended problems with well defined, sophomore level problem solving showed higher level thinking that is emphasized in upper level undergraduate courses.

Free response questions asked for concepts learned from the video their group selected, a concepts learned from another video, and any other thoughts about YouTube Fridays. A selection of responses (Table 3) provided details on what the students' liked and how they would change

Statements (n=number of responses)	Strongly Agree	Agree	Disagree	Strongly Disagree
I have a better understanding of the field of thermodynamics from participating in YouTube Fridays. (n=227)	3	60	28	10
I am better at relating real world phenomena to thermodynamics from participating in YouTube Fridays. (n=171)	12	67	17	4
I feel confident in performing engineering estimates after participating in YouTube Fridays. (n=171)	9	60	25	5
I think it is valuable to use 5 minutes of class time each week (~3% of total class time) to watch YouTube and not cover class material. (n=228)	21	59	15	5
I think YouTube Fridays helped me learn the material in DCGN 210 this semester. (n=228)	4	37	51	9

Table 2: Percentage responses to five statements on student surveys from pilots 3 and 4.

Real world problems are never as simple as those we are given in class. There are always other variables involved.
Thermodynamics are involved in everything – even slapping faces and an old woman hitting a car.
It's a fun way to see the real world examples of thermodynamics.
YouTube Fridays are very good practice for engineering estimate type questions and helped me to better understand how thermo is applied.
YouTube Fridays is a really cool way to get me jazzed about coming to class on Fridays.
YouTube Fridays are a good idea but the estimate calculated from the video should be presented. Watching the video is entertaining and can see where Thermo comes in, but not how to solve.
It is difficult to apply thermo to real world applications when very little data is present.
When a team does a YouTube Friday they should write an engineering estimate for the class to solve so that we actually learn something every YouTube Friday.
Good for concepts and real world stuff. Bad for learning hardcore engineering concepts.
Most of the difficulty comes from trying to measure all of the variables rather than the math portion of the problem.
Anything and everything, if enough assumptions are made can be represented by our equations!
Most things in life can be related to material balances.

Table 3: Samples of written comments from students upon the completion of Pilots 3–5.

YouTube Fridays. The relationship between real world phenomena and thermodynamics or materials and energy balances was mentioned numerous times, especially how real situations are much harder than class problems since there are so many unknowns. Another recurring comment from students before Pilot 4 was that they wanted to work the EE problem after watching the video each week to compare with the group selecting and writing the problem. This idea was implemented during

Pilot 4 and will be used in future semesters. The vast majority of the feedback on YouTube Fridays was positive and will help to refine the concept to improve the students' ability to apply classroom concepts (e.g., energy balances) to open-ended, real world situations.

CONCLUDING REMARKS

YouTube Fridays is a way to engage the digital savvy students while introducing open-ended problem solving. The student-led video selection and problem writing encouraged the students to use concepts from class to situations where some or all of the data is missing. A number of examples given in the paper (as well as in the appendix) illustrated the breadth of videos and questions related to two courses, introductory thermodynamics and material and energy balances. A running tally of the videos is available one of the author's web pages [9]. While the technique was developed in lower level engineering courses, smaller pilots have been completed successfully with other courses at the authors' institution. The more focused topics in upper level undergraduate courses would require additional detail in the assignment to parallel the course difficulty, content, and objectives. Technology will continue to revolutionize the college classroom and new pedagogical techniques will evolve (replacing YouTube Fridays) while accomplishing the same goal of teaching problem solving skills.

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REFERENCES

1. Kowalski, S.E., Kowalski, F.V. and Gardner. T.Q. *Lessons Learned When Gathering Real-Time Formative Assessment in the University Classroom Using Tablet PCs*. in *Proceedings of the 39th ASEE/IEEE Frontiers in Education Conference.* 2009. San Antonio, TX. http://fie-conference.org/fie2009/papers/1461.pdf

2. Choi, C.Q., *The Pull of Integrity.* Prism, 2009. **18**(7): p. 28-33.

3. Tapscott, D., *Grown up digital [electronic resource]: how the net generation is changing your world*. 2009, New York: McGraw-Hill.

4. Palfrey, J. and U. Gasser, *Born Digital: Understand the first generation of digital natives*. 2008, New York: Basic Books.

5. *Digital Natives blog*, in *Digital Natives*. 2009.

6. Pletka, B., *Educating the net generation: How to engage students in the 21st century*. 2007, Santa Monica, CA: Santa Monica Press.

7. Liberatore, M.W., *YouTube Fridays: Engaging the Net Generation in five minutes a week.* Chemical Engineering Education, 2010. **44**(3): p. 215-221.

8. Prince, M., *Does Active Learning Work? A Review of the Research.* Journal of Engineering Education, 2004(July): p. 223-231.

9. Liberatore, M.W. *Liberatore Rheology Laboratory Home Page*. 2010 [cited 2010 August 16]; Available from: http://rheology.mines.edu.

10. *Sledding failure*. [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=eqLWb0DK1wc

11. *Windmill/Wind Turbine Explosion*. [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=7nSB1SdVHqQ.

12. *Flaming Bacon Lance of Death, from Theo Gray's book "Mad Science"* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=w9dskxN10N0.

13. *Mythbusters water heater* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=JmJoyuUJj2Q.

14. *Water Phase Change - Water to ice in 90 seconds using vacuum* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=pOYgdQp4euc.

15. *Big Water Slide + Jump!* 2010 [cited 2010 August 24]; Available from: http://www.youtube.com/watch?v=9fLBl_7qL2E.

16. *MythBusters: Adam's Super Slide*. 2010 [cited 2010 August 24]; Available from: http://dsc.discovery.com/videos/mythbusters-adams-super-slide.html.

17. *#1 Vertigro - Gas, Diesel, Biofuel production from algae* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=vxNeBQCRv1c.

18. *Rotary Dryers for Wood and Biomass Pellet Plants* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=lO4YTcoyU5o.

19. *How Condoms Are Made* [cited 2010 August 16]; Available from: http://www.youtube.com/watch?v=u22BbGNzLWo&.

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APPENDIX

A.1. Additional examples of Engineering Estimate problems based on YouTube Videos

Sledding Failure www.youtube.com/watch?v=eqLWb0DK1wc

In one video, an individual rides a sled starting at the top of a hill with an initial velocity of 0 m/s. At a certain time, the sled-rider is going 10 m/s. Find the height of the hill at the instant the rider is going 10 m/s. The rider continues down the hill and impacts a car (z = 0 m) when all the kinetic energy is transferred from the rider to the vehicle. Find the velocity immediately before the impact with the car and the total kinetic energy transferred to the vehicle.

Fire Hose Car www.youtube.com/watch?v=VxT281HP1rc

After observing the video, determine the ratio of the inlet area to the outlet area of the nozzle in order to create a large enough increase in velocity of the water flow to lift the car.

Fluidyne Prototype (Carnot Heat Engine) www.youtube.com/watch?v=labu8hx8fgU

Determine the value of Q_H and what type of process (reversible, irreversible or impossible) based on the efficiency.

A.2. Titles and URLs of YouTube Videos from Pilots 3, 4, and 5

	Pilot 3 Video titles	**Link**
1	Diet Coke and Mentos Rocket: The Best Way	http://www.youtube.com/watch?v=2wfppG7Tt0k
2	Diet Coke/Mentos Rocket	http://www.youtube.com/watch?v=VWS0FZEqdJA
3	Reaction of Sodium & Chlorine (with subtitles)	http://www.youtube.com/watch?v=Mx5JJWI2aaw
4	Molten Metal Thermite Car Demolition	http://www.youtube.com/watch?v=1bvPdgS2Pjg
5	Table top RC boat steam engine	http://www.youtube.com/watch?v=pPnVB3D0lYs
6	Egg in a Bottle	http://www.youtube.com/watch?v=ctJyu5ete6Y
7	The great expansion	http://www.youtube.com/watch?v=gVDG_DZ5874
8	Big guy launches scrawny kid in Blob!	http://www.youtube.com/watch?v=HDw_qqkRqRM
9	Dry Ice	http://www.youtube.com/watch?v=cTP4yp8y_NA
10	Grape Plasma	http://www.youtube.com/watch?v=0LCK3jrfVVE

11	Doctor Doctor - Steel Drum Implosion	http://www.youtube.com/watch?v=j2k40Hw3GI0
12	Flaming Bacon Lance of Death, from Theo Gray's book "Mad Science"	http://www.youtube.com/watch?v=w9dskxN10N0
13	Mythbusters water heater	http://www.youtube.com/watch?v=JmJoyuUJj2Q
14	Exploding CD	http://www.youtube.com/watch?v=8KvRe4hJyjU
15	Bizzare Ice	http://www.wimp.com/bizarreice
16	The Rubber Band Heat Engine	http://www.youtube.com/watch?v=dBXL93984cQ
17	Exploding watermelon - liquid nitrogen 1	http://www.youtube.com/watch?v=AzmZ6w_14EA
18	Windmill/Wind Turbine Explosion	http://www.youtube.com/watch?v=7nSB1SdVHqQ
19	Sleepy Granny strikes back	http://www.youtube.com/watch?v=4AyGMTk4vnw
20	Super Slow Mo Slap In The Face - Digg Reel	http://www.youtube.com/watch?v=LRHK0K2ii6Q
21	mclaren f1 crash	http://www.youtube.com/watch?v=zGjHZX-_UDw&
22	How to Shoot an Anvil 200 Feet in the Air	http://www.youtube.com/watch?v=IhQ4dE_RGnQ
23	Mythbusters - Compact Compact Rocket Sled	http://www.youtube.com/watch?v=aSVfYwdGSsQ
24	Soap in Microwave	http://www.youtube.com/watch?v=7IAOOwMNodA
25	Mentos and Diet Coke – how much energy to shoot the coke fountain.	http://www.youtube.com/watch?v=hKoB0MHVBvM
26	Atom Bomb – how much water vaporized	http://www.youtube.com/watch?v=QptDY5QdeXE
27	Big Water Slide + Jump!	http://www.youtube.com/watch?v=9fLBl_7qL2E
28	From Boiling to Frozen	http://www.youtube.com/watch?v=zFj_i6HtebM
29	Mythbusters - Helium and Sulfur Hexafluoride	http://www.youtube.com/watch?v=5Ip4Sa5ZtBQ
30	sprinkler cat	http://www.youtube.com/watch?v=ccviA9L7Bvg
31	Melting steel with solar power	http://www.youtube.com/watch?v=8tt7RG3UR4c
32	Brainiac Alkali Metals	http://www.youtube.com/watch?v=m55kgyApYrY&feature=related

33	Caesium in Water - Periodic Table of Videos (the real thing)	http://www.youtube.com/watch?v=5aD6HwUE2c0
34	Superheated Steam - Cool Science Experiment	http://www.youtube.com/watch?v=R9uvIhgVz04
35	Ship floating on nothing! :: Physikshow Uni Bonn	http://www.youtube.com/watch?v=1PJTq2xQiQ0
36	Diet Coke/Mentos Rocket	http://www.youtube.com/watch?v=VWS0FZEqdJA
37	Ferrofluid Piston	http://www.youtube.com/watch?v=21WzdjqAG0s
38	Thermodynamics In Action	http://www.youtube.com/watch?v=AM_GAbvacbE&NR=1
39	WoRks!	http://www.youtube.com/watch?v=-XWF36SyJqY

	Pilot 4 Video titles	**Link**
1	Greased Lightning (grease fire)	http://www.youtube.com/watch?v=hwUTdZj6r40
2	Ice by Boiling Water (vacuum)	http://www.youtube.com/watch?v=pOYgdQp4euc
3	Liquid Nitrogen Balloon	http://www.youtube.com/watch?v=I5rYqexAyA0
4	Whoose Bottle	http://www.youtube.com/watch?v=DjCum6yu8M
5	Sledding Failure	http://www.youtube.com/watch?v=eqLWb0DK1wc
6	This Too Shall Pass	http://www.youtube.com/watch?v=qybUFnY7Y8w
7	Fireproof Balloon	http://www.youtube.com/watch?v=nI_FBbjRPI
8	Antiacid Jail Break	http://www.youtube.com/watch?v=Px8hi105Hec
9	Fire Hose Car	http://www.youtube.com/watch?v=VxT281HP1rc
10	Liquid Nitrogen Swimming Pool	http://www.youtube.com/watch?v=w2mj-Sq2eoe
11	Air Cannon	http://www.youtube.com/watch?v=D90tEribOMM
12	Rubber Band Heat Engine	http://www.youtube.com/watch?v=OW6aEmOsXv0
13	Burning Thermite	http://www.youtube.com/watch?v=GSTILQRPVRA
14	Tree Branch on Electric Line	http://www.youtube.com/watch?v=q4ph-h7I_aM
15	Induction Heating	http://www.youtube.com/watch?v=aLwaPP9cxT4
16	Pants Full of Helium	http://www.youtube.com/watch?v=1I_v1K3GwUc
17	Ski Jump Record	http://www.youtube.com/watch?v=Q4c4DhVVAwU
18	Freezing Beer (nucleation)	http://www.youtube.com/watch?v=fYcpveAT8JY
19	Fluidyne Prototype (Carnot HE)	http://www.youtube.com/watch?v=Iabu8hx8fgU

	Pilot 5 Video titles	Link
1	Photo Chemical Etching Process	http://www.youtube.com/watch?v=M86k7urL0H0
2	Chemical Production Engineering Technology Video (sadly removed)	http://www.youtube.com/watch?v=xfq8mvQNPck
3	Chemical Engineer (Unilever)	http://www.youtube.com/watch?v=iud7js7J36k
4	DeltaV: Sizing Up Results at Eastman Chemical Company	http://www.youtube.com/watch?v=V0ugyy9QmwM
5	The Future of Chemical Engineering	http://www.youtube.com/watch?v=A3kQLyBxHC8&feature=fvw
6	Introduction to Simulating Chemical Engineering Applications	http://www.youtube.com/watch?v=r0HHWEUz8Yc
7	Eng project 1 (chemical engineering)	http://www.youtube.com/watch?v=M-yrQZqYyJQ
8	Engineering Your Future - Biochemical Engineer (P&G)	http://www.youtube.com/watch?v=u67ML2j74Lw
9	Light (Dependant) Reactions of Photosynthesis Animation	http://www.youtube.com/watch?v=eY1ReqiYwYs
10	#1 Vertigro - Gas, Diesel, Biofuel production from algae	http://www.youtube.com/watch?v=vxNeBQCRv1c
11	Rotary Dryers for Wood and Biomass Pellet Plants	http://www.youtube.com/watch?v=lO4YTcoyU5o
12	A car that runs 200 miles on compressed air.	http://www.youtube.com/watch?v=ztFDqcu8oJ4
13	Cool Stuff Being Made: The Metal Forging Process	http://www.youtube.com/watch?v=PXVWiGqeltM&feature=related
14	How its made-beer	http://www.youtube.com/watch?v=0LGqg41i3VY&
15	How Condoms Are Made	http://www.youtube.com/watch?v=u22BbGNzLWo&