Case Study for a First-Year Seminar: A Plan Which (mostly) Worked

Richard Englund
The Pennsylvania State University at Erie

Abstract

A First-Year Seminar is now required for all students entering Penn State University. The goal is to provide interaction between faculty and small groups of students early in every program of study to personalize the university, to get the students to work collaboratively from the start, and to introduce the students to academic life. Some of the offered seminars are general, applicable to any major, and other seminars are included in courses specific to particular majors. An introductory engineering technology course titled "Manufacturing, Materials, and Processes" has been modified to include a seminar and is effectively required for all students entering a range of majors.

One of the goals for this particular seminar class is to acquaint the students with the courses in their majors, and how the courses integrate with the goals of the major. A case study was developed based on a damaged lawn mower, and presented in the seminar. The problem presented in the case study was purposely incomplete, with a series of tasks listed which would be necessary to resolve the damage to the lawnmower. The students were required to search the courses of their major to determine which course provides the tools to accomplish the listed tasks. The case study was re-visited in a subsequent week for concluding remarks about the integration of the courses in the major.

The case study is presented in this paper, and suggestions for development of other case studies applicable to first-year students. Additional information presented in a subsequent class is described, as is an evaluation of the benefits of the case study as it was presented the first time. Observations for improvement of the effectiveness of case studies in first-year seminars are also presented.

Development of a Case Study

Entering freshmen often come with little experience and few skills applicable to engineering tasks, yet they resent spending up to four semesters in preparation for engineering courses. The movement to first-year experiences in engineering is intended to introduce them to the techniques of the profession early in their program of study, and to motivate the students to study in the support courses. Often the students have no knowledge or experience to use as a base for such an introduction. Technical content of case studies for first-year must be (1) limited to that which can be explained in the case study, or (2) is generic enough that all students can be expected to have some experience with the device or subject. In an introductory seminar, the

case study must also be brief since generally such seminars have limited class hours and it is not desirable to devote more than a period or two to any one case study. This is unlike the sort of case studies prepared for more advanced audiences, such as the excellent case studies written over past years and available from the Carleton University web site[1].

The case study presented below follows these two requirements. First, the centerpiece for the case study is a lawn mower, and for the population served by this case study a lawn mower is almost universally familiar to the students regardless of gender or city/suburb homes. In contrast, farm machinery is familiar to few students and hence would not make an effective example. Secondly, in an attempt to improve the students' technical knowledge base as it applies to the device described in the case study, a simple explanation of the operation of a 4-cycle engine is included in the case study. Descriptions used in the case study must begin from everyday items or from high school general science. The case study presented below was four pages as originally formatted, easily within a single class period for reading and discussion.

Case Study Title : I Don't Know What Happened; It Just Quit!

Introduction to Case Study:

A lawn mower is a device familiar to most of us. Not everyone has operated one, to be sure, but in this part of the country there is enough rain that if an area is not mowed it will soon grow up to brush or trees. At my house there are some areas that I only mow occasionally, just to keep from having tall stuff growing there. It cannot be called lawn because it is much too rough for that, but it does get mowed sometimes.

In midsummer of 1999, I made an effort to mow the usual spots, including one full of poison ivy. The former owner of my house had tossed junk various places out back, and to my surprise I found that some pipes had been left in this patch of poison ivy. I am not very interested in fishing around in poison ivy to see if it happens to have something in it, so some earlier year I had pulled out all the pipes I could see, and then started mowing. This year when I mowed it I got the nasty surprise of the lawn mower finding another pipe. Whether this pipe had been there all along and I missed it previous years, or 1999 was such a dry summer that the soil changed and exposed it anew, or some child had thrown it there the day before, I know not. In any case, the mower came to an abrupt stop. The noise told the story immediately; there is no sound quite like a mower blade hitting a pipe.

I tried to re-start the engine, but the rope could hardly be pulled. Since it was very hard to get the engine to rotate, I suspected mechanical damage and tipped the mower on its side. I expected a bent blade but it was not. Instead I found that the engine crankshaft was bent at the bottom of the engine.

Background for Case Study:

While it is assumed that most people have a passing familiarity with lawn mowers, it is not assumed that very many have ever taken one apart, particularly the engine. Hence a description of what is inside is supplied here.

At the most basic level, an engine is a device which burns fuel in air to get some heat, uses the heat to expand the air, and the expanding air to apply a force to get a job done. A lawn mower engine is a fairly simple example, but the details are beyond what we must know here, and that is a good thing since a lifetime can be spent studying some of the details. Even though not really necessary for repair of the bent crankshaft, it won't hurt anyone to have a basic understanding of the operation of an engine, so we will take a detour to think about the thermal and fluid operations of the engine.

The first trick that is necessary is to get the right amount of fuel and air into the combustion chamber. The operator controls the amount of the mixture that is drawn in by the position of the control lever, which in turn controls the position of the throttle plate in the intake system. In a conventional engine, the throttle plate is in a carburetor, which also mixes the correct amount of fuel into the air. Should you have the opportunity to study fluid mechanics at some time, the principles will assist in describing this device and understanding its operation, but in short the total energy of the air is the same at all locations as it is drawn through the carburetor. Some of the energy is seen as pressure and some is seen as velocity. Because the area drops in the venturi, the velocity increases. But for the velocity to increase requires energy, which must come from a reduction in pressure, and the atmosphere can push fuel from the float bowl into the reduced pressure of the air stream in the venturi.

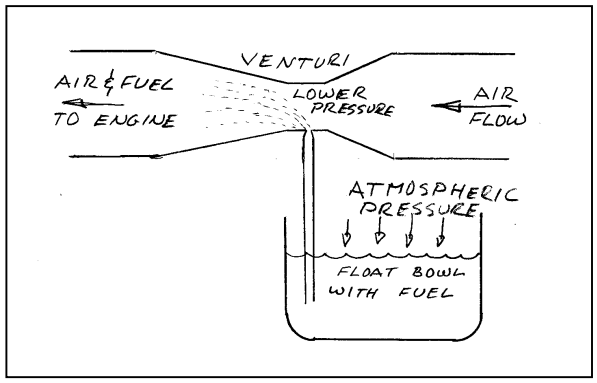


Figure 1: Simplified Carburetor

Getting this explosive mixture into and out of the engine requires some valves and a mechanism to open and close the valves, but we will ignore the mechanism here. The usual lawn mower has what is called a 4-cycle engine. The 4 cycles are intake, compression, power, and exhaust. Shown in Figure 2 is the intake cycle or stroke; the crankshaft rotates, pulling the piston down, drawing air and fuel from the carburetor. At the completion of the intake stroke the intake valve is closed, and the crankshaft pushes the piston back to the top to compress the air-fuel mixture. The power stroke begins with the sparkplug firing, very rapid burning of the fuel (in other words an explosion), heating and high pressure in the cylinder from the burning, and the piston is pushed down by the pressure. Finally the exhaust valve (not shown) is opened, and the crankshaft pushes the piston back to the top and in the process shoves the combustion products out.

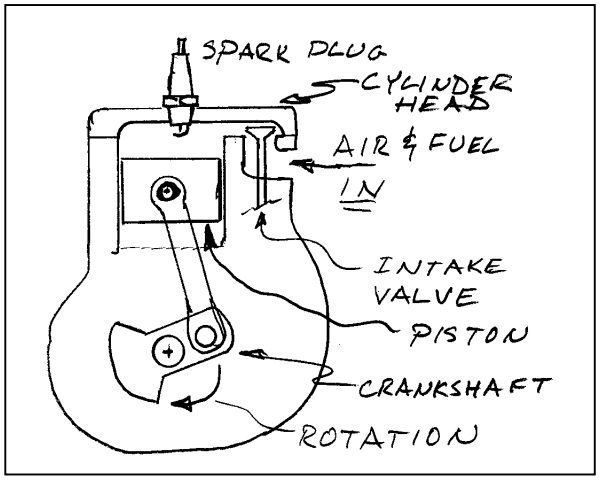


Figure 2: 4-cycle Engine, top view

Case Study Description of the Problem:

At the bottom of the crankshaft is the blade. Usually the blade is directly attached to the crankshaft by a key in a keyway, and some form of shaft adapter to transmit the engine torque to the blade. Usually also there is a screw to hold the blade from falling out of the blade adapter. If this sort of direct connection is not employed, there may be a clutch which connects the shaft to the blade when the operator grips the mower handle but permits the engine to continue to rotate with the blade stopped when the operator releases the handle. The particular mower in this incident was directly connected as shown in Figure 3.

Figure 3: Crankshaft

Not shown in Figure 3 is the physical mechanism which bent the blade. In general, the user of a lawn mower enjoys a benefit from rotational inertia of the blade and engine. If a clump of heavy grass is encountered, the inertia of the system tends to carry the blade through the clump. For a large patch of heavy grass, the load on the engine will slow it down a bit, and the speed regulation governor will apply more power to speed the engine back to the setting chosen by the operator. When the blade is suddenly stopped, the benefit turns into a liability. In Figure 3, the near end of the blade was stopped when it struck the pipe. The rotational inertia of the blade was still present, but since one end of the blade had stopped, the only way for rotation to continue was for the far end to move, bending the crankshaft. The amount of bending of the crankshaft is an indication of the amount of energy present in rotational inertia. Rotational inertia is a form of kinetic energy, and the force required to bend the crankshaft multiplied by the distance bent is an amount of work. It would be a fair assumption that the bending work is roughly equal to the inertia present just before impact with the pipe.

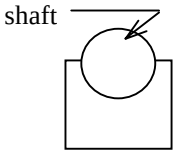
About 1/3 of the way down the picture in Figure 3 is the throw for the connecting rod. Immediately above and below the throw are the balance weights on the crankshaft which are designed to balance the weight of the connecting rod. Below the lower balance weight is the camshaft drive gear. The camshaft, driven by this gear, is the device which causes the valves to open and close at the desired times. Further above and below the balance weights are the main crankshaft journals; these are where the crankshaft turns in its bearings. Scrutiny of the photograph will show that the crankshaft is visibly bent from the lower journal to the blade adapter. This is where we must direct our attention.

Case Study Assignment:

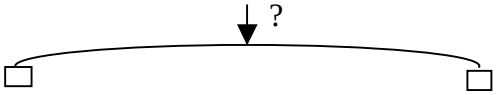
My lawnmower is out of service due to the bent crankshaft. I would like to straighten the crank, but do not wish to return it to service if it will not be safe upon return. Several tasks are

necessary to perform the repair and checks of safety. You are to identify the course or courses where the skills necessary to accomplish each of the tasks below are scheduled to be taught:

- Measure journal diameter and shaft diameter at location of blade attachment
- Draw sketch of support blocks and loading blocks, with dimensions. Want semi-circular supports for shaft and another block with semi-circular opening for pressing on the shaft. If I push on, or support the shaft, with a flat surface I may leave flat spots on the shaft.



- Make the support and loading blocks (just a hint – this is not taught in a course regularly scheduled for PLET students)
- Find material properties for cast iron
  - Estimate the stress required to get yielding
  - Estimate how much bending may be applied before cracks begin
- When supported in the blocks at the ends of the bent section, determine the required force to get a stress in the shaft equal to the estimated yield stress.



- When loaded for straightening, determine the loads present at the supports.
- Non-destructively examine the shaft, looking for cracks. (I have no interest in straightening the shaft if I cannot be assured of its integrity when the repair is completed.)
- Measure the straightness of the shaft to determine whether repair operations are complete.

Case Study Resources Required:

A list of courses required for the 2MET and 2PLET degrees (check sheet)
Course descriptions, either web version or printed PSU Bulletin
Course syllabi for courses in which you are currently enrolled

Results of Case Study Assignment

The text[2] used for this seminar course discusses the disciplines of engineering technology, the factors related to success as a student and practitioner in engineering technology, and provides motivation for lifelong learning. The students had, in their view, been bombarded with encouragement to work collaboratively, to be sure that they have selected the correct major for their interests, study diligently and use their time wisely, and use the information resources provided. When presented with the case study, the students delivered the strong message that they approved of an applied presentation rather than more lectures on how to study. Many questions were raised regarding the content of the case study, particularly in regard to the operation of an engine, and why lawn mowers are designed as they are.

The homework assignment was intended to “sell” the students on the idea that they would find real value in future courses in their major. Instead, the students chose to answer the questions regarding curriculum by searching all Penn State course descriptions on the world wide web, and writing down numbers for courses not offered at this location, nor applicable to their major. Instead of learning that their major offered courses and skills that would help them solve real problems, they got the vague notion that there were specialized courses somewhere in the university which would answer specific questions. It is clear that the assignment must be very limited to produce the desired result; it must constrain the range of possible choices in some way.

The case study assignment, as viewed by the students, did not give them any inkling that there was useful knowledge offered in specific courses of their majors. It did prepare them to hear descriptions of the sorts of tools they would acquire in future courses, and they were not ready to hear such descriptions prior to the case study assignment. When the (unsuccessful) written assignment was returned, the students eagerly listened to the course content and goals for the courses they will be expected to take in their major which would allow them to handle tasks described in the case study. When used again, reading the case study will be assigned before the period it is discussed, but not written answers to the specific set to questions. The questions were a better discussion vehicle than graded assignment.

In a subsequent week, reading of a case study on ethics[3] was assigned, with questions posed to the readers before the class. Classroom discussion of the case study and of the questions was spirited, and written answers to the questions were thoughtful and coherently argued.

Conclusion

Case studies can be effective teaching and learning tools in first-year seminars if written and used in a way appropriate to the audience. Based on this writers experience, to be effective for the majority of students in first-year seminars, case studies must be short, provide full explanation of technical subjects beyond high school general science, and describe equipment or situations already familiar to the readers. Discussion questions and a written assignment should be read by the students prior to class discussion, but the written assignment should be a continuation of the classroom discussion rather than independent work by the student. The set from which answers to written assignments may be selected must be constrained to the desired range to keep students focused on the subject at hand. The primary value in the case study is preparation of the students for classroom discussion.

Bibliography

1. URL: http://www.civeng.carleton.ca/ECL/; Engineering Case Studies.
2. Cheshier, S. R., *Studying Engineering Technology: A Blueprint for Success*. Discovery Press, 1998.
3. URL: http://lowery.tamu.edu/ethics/ethics/giftgive/giftgiv1.htm; Engineering Ethics, Accepting Gifts and Amenities, Student Handout.

RICHARD ENGLUND
Richard Englund is currently an Assistant Professor of Mechanical Engineering Technology at The Pennsylvania State university at Erie, The Behrend College. He received a BSME from Washington State University and an MSME from the State University at Buffalo. Mr. Englund is a registered Professional Engineer in Pennsylvania and is actively involved in new product design and research with industry. Prior to teaching he was a design engineer and stress analyst in industry.