

Big Fish: The Lost Art of Story-Telling in the Engineering Classroom

Abstract

Story-telling is frequently a lost art in the engineering classroom. Often, engineering educators feel that telling stories is a distraction to communicating the necessary content of a course. In contrast, this paper describes story-telling as an improvement to traditional teaching techniques. Story-telling may be used as a method to illustrate important points, give coherent meaning to seemingly divergent topics, aid students in remembering content, or simply to break up a long lecture. The author has used story-telling extensively in the engineering classroom. A consistent comment from students in end-of-semester evaluations is to include more stories in subsequent offerings of the course. The paper will present methods and findings from using story-telling in technical course offerings.

Introduction

Story-telling is a lost art in the engineering classroom. Engineering educators may feel that telling stories is a distraction or divergence to communicating the necessary content of a course. However, it is possible to use story-telling as an improvement to traditional teaching techniques.

Story-telling may be used for the following reasons:

- To illustrate important points;
- To give coherent meaning to seemingly divergent topics;
- To aid students in remembering content;
- Or, simply to break up a long lecture.

The author is on the faculty in the Electrical Engineering and Computer Science Department at the University of Michigan. He has used story-telling extensively in all of his classes, including junior-level Data Structures and Algorithms, and senior/grad-level Software Engineering courses. Story-telling also fits naturally into a Professionalism and Ethics course that he frequently teaches.

This paper describes story-telling as a teaching method. Several examples are used to illustrate the use of story-telling for different purposes. Dos and Don'ts are listed. Finally, the paper gives a summary.

Story-telling Examples

By way of illustration, the author lists four examples of using story-telling in the classroom. In each example, the discussion is partitioned as follows: **The Topic** describes the environment and objectives of the story, and also describes how the material might be communicated without using stories; **The Story** is a re-telling of the actual story; and **The Lesson** discusses the knowledge that is gained by the students as a result of teaching the material using story-telling.

Example 1: Story-telling to illustrate important points

The Topic. I do group work in many of my classes. Many times, the students are accustomed to working in a competitive environment, rather than a cooperative environment. Therefore, they are often not well-equipped to work with fellow students.

This lesson is about working in groups. In a non-story environment, the teacher might say that working together is important because it is the best way to gain a comprehensive solution.

The Story. I was visiting my grandparents once. As a result of being married for over fifty years, they had developed the science of the debate to a fine art-form. As a sidebar story, I remember seeing a Woody Allen movie once where the character's grandparents were in the next room debating. In the background of the movie was heard "No, no, the Pacific Ocean is a way better ocean than the Atlantic Ocean". That is about the level of art that my grandparents had developed. But, I digress.

As I walked into the Living Room of their home, my grandparents were sitting in their usual chairs in opposite corners of the room. I was wearing one of my favorite shirts at the time that had Y-A-C-H-T spelled in a semi-circle across the top of the sweatshirt.



Figure 1. My Sweatshirt.

Because my grandparents were sitting in opposite corners of the room, my grandmother could not see the 'T' on my sweatshirt and my grandfather could not see the 'Y' on my sweatshirt.

My grandmother asked me "Honey, what is a 'YACH'?" Without missing a beat, my grandfather said "Sylvia, the shirt says A-C-H-T. The word is 'ACHT', not 'YACH'. By the way Sonny, what is an 'ACHT'?"

At this point they began the first debate of the day and I went back into the kitchen to eat a delicious fried bologna sandwich (with mayo and lettuce) that my grandmother had cooked for me.

The Lesson. Clearly, we operate in a world of partial knowledge. We often have only a portion of the complete knowledge that is necessary to solve a problem. Often times, the knowledge that we have overlaps with someone else's partition of knowledge. When confronted with the other partition, we can either insist that the other person is wrong (as my grandparents seemed to do above), or use each other's partial knowledge to come up with the global, correct solution. I will often use an example exercise where each student in a group is intentionally given partial knowledge of the solution, but the group is required to develop a global solution.

Example 2: Story-telling to give coherent meaning to seemingly divergent topics

The Topic. Algorithmic efficiency is a key point for a Data Structures and Algorithms class. In short, some algorithms work more quickly than others. As an example, a sorting algorithm may work in quadratic time ($O(n^2)$) or logarithmic time ($O(\log n)$). The speed of determining the solution is directly dependent upon the size of the data set (e.g., size of n) and the efficiency of the algorithm.

The Story. My wife (Jean) and I are teaching our kids to clear the dinner table after our family has finished eating. Our family is trying to determine the best method of clearing, given the number of people that are coming to dinner and the limitations of each person who is clearing the table.

Assume that there are several guests at the dinner table in addition to our family. But, we do not know how many guests. Also, assume that each person has the same number of pieces that make up their respective place setting, such as an entrée dish, salad dish, dessert dish, knife, spoon, fork, ...

There are three different approaches to clearing the table.

In the first approach, one of the adults buses half of everything that is on the table in one trip. Then, the adult returns to the table and buses the remainder of the place settings.

In the second approach, the oldest child moves one complete place setting from the table to the sink with each round-trip.

In the third and final approach, the youngest child moves only one item (a single item from each place setting from each person), with the exception of the knives. She never touches the knives because she is too young. After our youngest daughter has completed her portion of the work, our middle daughter moves all of the knives in one trip from the dinner table to the kitchen sink.

Clearly, some methods are more efficient than others. What is the relative efficiency of each?

The Lesson. The lesson is that the approach to the problem directly affects the efficiency of the solution. The efficiency is directly dependent upon the size of the place setting and the number of people at the table. When both of these values are small, then efficiency is not too important. As these values grow, efficiency becomes more and more critical.

The study of efficiency applies to software algorithms as well. For very large data-sets, efficiency is paramount. The notation used to describe algorithmic efficiency is called $O()$ (pronounced “big-oh”).

In the first method, clearing the table is independent of the number of people or the size of a place setting. That is, the algorithm for clearing the table is constant, or $O(1)$. That is, if we assume that a parent has ‘infinite strength’, then busing the table will always take two trips.

In the second method, clearing the table is independent of the size of the place setting (called *size_setting*), but is dependent upon the number of people at the dinner table (called *num_people*). That is, the algorithm for clearing the table with the second approach is linear and dependent upon *num_people*. This is called an $O(\textit{num_people})$ or linear algorithm.

The third approach is the most complex, and perhaps the most interesting. Recall that we have a variable for the number of people called *num_people* and also a variable for the size of a place setting, called *size_setting*. The third approach is dependent upon both *num_people* and *size_setting*. It is derived as follows:

My youngest daughters will bus all pieces of each setting except one, which is $(\textit{size_setting} - 1)$. The number of place settings is *num_people*. Finally, there is a single trip where our middle daughter moves all of the knives to the sink.

$$(\textit{num_people} \times (\textit{size_setting} - 1)) + 1$$

Equation 1. Derivation of efficiency for third approach.

In proper $O()$ notation, small constants such as 1 are disregarded. Therefore, the third approach has efficiency that is $O(\textit{num_people} \times \textit{size_setting})$, or is called a quadratic algorithm.

The story illustrates the relative efficiency of three different approaches to the same problem. Algorithmic efficiency is critical to writing computer software that executes quickly.

Example 3: Story-telling to aid students in remembering content

The Topic. As part of the Data Structures and Algorithms course, I often cover some basic material related to encryption. An early method of encryption was a mono-alphabetic cipher. In a mono-alphabetic cipher, each letter in the initial alphabet is substituted with a new letter from the cipher alphabet. That is, ‘d’ might be substituted with ‘X’, ‘o’ might be substituted with ‘R’, and ‘g’ might be substituted with ‘J’. Therefore, the initial word ‘dog’ is encrypted as ‘XRJ’.

Many might consider basics of encryption to be somewhat dull. I introduce some history to lend context to material from the excellent book *The Code Book*, by Simon Singh [1].

The Story. The history that is used to teach the lesson is from the 16th century and deals with two cousins, Mary Queen of Scots and Queen Elizabeth, who both desired to be Queen of England. Queen Elizabeth had Mary Queen of Scots imprisoned and was searching for some way to have Mary executed so that Elizabeth’s claim to the throne would be uncontested.

On the morning of Wednesday, 15 October 1586, Queen Mary entered the crowded courtroom at Fotheringhay Castle. Years of imprisonment and the onset of rheumatism had taken their toll, yet she remained dignified, composed and indisputably regal. Assisted by her physician, she made her way past the judges, officials, and spectators, and approached the throne that stood halfway along the long, narrow chamber. Mary had assumed that the throne was a gesture of respect towards her, but she was mistaken. The throne symbolized the absent Queen Elizabeth, Mary’s enemy and prosecutor. Mary was gently guided away from the throne and towards the opposite side of the room, to the defendant’s seat, a crimson velvet chair.

Mary Queen of Scots was on trial for treason. She had been accused of plotting to assassinate Queen Elizabeth in order to take the English crown for herself. Sir Francis Walsingham, Elizabeth's Principal Secretary, had already arrested the other conspirators, extracted confessions, and executed them. Now he planned to prove that Mary was at the heart of the plot, and was therefore equally culpable and equally deserving of death. [1]

At this point, the students are hooked. I talk about mono-alphabetic ciphers. Described briefly above, mono-alphabetic ciphers are an encryption scheme where letters in an initial alphabet are substituted with letters from a cipher alphabet.

I discuss the difference between ciphers and codes. Codes are substitutions where words are replaced with symbols that represent the words. So, for example, all occurrences of the word 'king' might be replaced by the symbol '◇'. I discuss that using just ciphers is called *enciphering* and using just codes is called *encoding*, but using both is called *encryption*.

Getting back to the history lesson, Queen Elizabeth was looking for some proof that Queen Mary was plotting to have her assassinated. One of Queen Mary's followers, Anthony Babington, was sneaking encrypted letters to and from her while she was in prison. A letter from Babington to Mary included the following text that was secretly captured and decrypted by Queen Elizabeth's master spy:

Myself with ten gentlemen and a hundred of our followers will undertake the delivery of your royal person from the hands of your enemies...who for the zeal they bear to the Catholic cause and your Majesty's service will undertake this tragical execution. [1]

This meant that Mary's followers were indeed planning to assassinate Queen Elizabeth. But, Queen Mary needed to give her assent to the plan in order to be complicit in the crime. Finally, Mary sent the following encrypted reply:

I will be glad ... to give you some further advice necessary to be followed therein, as also from time to time particularly how to proceed. [1]

This, without question, was Mary agreeing to the assassination of her cousin Elizabeth.

At this point, I discuss frequency analysis which is a method used to determine the frequency of letters occurring in the encrypted message. The frequency of letters in the encrypted message is compared with the frequency of letters in a typical un-encrypted page of text. As an example, in a page of any given novel, the letter 'c' will occur approximately 8.1% of the time. Therefore, any letter occurring in the encrypted message approximately 8% of the time has some likelihood of being the letter 'c'.

The students work on some simple example of decryption (perhaps the above letters to and from Queen Mary). Finally, I read the tragic (and somewhat gory) conclusion to the historic tale. This narration is written by Richard Wingfield, who presumably, was present at the execution on February 8, 1587.

Then she laide herself upon the blocke most quietlie, & stretching out her armes and legges cryed out ... & at the laste while one of the executioners held her slightlie with one of his handes, the other gave two strokes with an axe before he cutt off her head ... [2]

The Lesson. As mentioned, the story is about encryption. I have taught this material both with and without the historic perspective, but the history really adds impact. By the end of the lesson, the students have learned about enciphering, encoding, encryption, mono-alphabetic ciphers, frequency analysis, and a small piece of English history.

Computer science, as in many other technical fields, has a rich history. As examples, Alan Turing (Enigma Code), Charles Babbage (Difference Engine) both have very colorful histories. Using this history in teaching the technical lessons contributes greatly to its context and depth.

Example 4: Story-telling to break up a long lecture

The Topic. Research shows that the attention span of a typical college student is approximately 18 minutes [3]. It is desirable to have students complete some type of activity after this interval to revive their respective attention. Examples of activities might be a small cooperative question, think-pair-share, and many other methods. Story-telling is yet another tool to bring the student's attention back into the course material (or give them a brief respite).

The Story. After completing his college, my brother was living the good life and had become rather portly. He and his wife Julie had a Chihuahua named Bambi. First, let me state that a Chihuahua is not a good dog to have in Michigan, as they really do not like the cold. As a result, Bambi always crawled under the blankets while my brother and sister-in-law slept.

Doug (my brother) lived in fear of rolling over on top of Bambi and crushing her.

Once, Doug woke up in the middle of the night and saw, in the darkness, a lifeless mass on his pillow. He picked it up and dropped it, with a thud, back onto his pillow. He picked it up again, and dropped it again. Fearing that he had rolled over and crushed his beloved dog, he hollered to his wife next to him in bed "Julie, Julie, turn on the light. I crushed Bambi and she's dead here on my pillow".

Julie turned the light on and they both looked at Doug's pillow. There, lying on his pillow, was his own arm. It had fallen asleep, and in the darkness of the night, he had confused his own arm (which had fallen asleep) with his dog, Bambi. Bambi peaked out from under the blankets wondering what all the fuss was about.

The Lesson. Often, after telling this story, I ask the students what the lesson is. As I most often tell stories that are directly tied to the material, they often come up with some creative relevance to the story. In reality, there is no relevance. It is just a good story.

Dos and Don'ts to Story-Telling

I would like to offer some dos and don'ts for story-telling. These are based upon experience from the past few years of story-telling in the classroom.

- Do stick to the important parts of the stories. Many stories (and story-tellers) die a lingering death by adding too much attention to irrelevant details of the story. As an example, consider this: "I would like to tell you a story about something that happened to me a year ago. Well, actually, it was a year and a half ago in spring-time. No, I'm mistaken, it wasn't spring-time, and it was January. I think that it was January 5th. No, it was February 5th, because I remember that it was just before Valentine's Day."

Unless the specific date is highly relevant to the story, I have lost the audience due to attention to detail that is completely unrelated to the story.

- Don't confuse stories with history. If you are using history (as in the Mary Queen of Scots story above), then by all means make sure that the history is factual and accurate. But, if you are telling a story to illustrate a point, then do not get bogged down in detail. That is, in the table clearing story above, it really does not matter whether or not I allow my youngest child to clear the knives from the table. But, it makes a more interesting problem when she does not clear the knives. Similarly, I could have used a different word (rather than 'YACHT') in the first story.
- Do watch the student's reactions. Some students do not want to hear stories. Some faculty are not natural story-tellers. Give it time, and work into it slowly. As with other teaching techniques, one should ease into any new approach to see if it fits her/his teaching style and the student's learning style. Also, do not give up after just one try. Give yourself some time to hone your skills.
- Don't become a Cap'n Jack. As an undergraduate student, I had a college professor who would tell war stories of the time he spent in the Vietnam War. I do not remember the professor's name, but his nick-name was Cap'n Jack. He would often tell stories about the horrors of serving in the war. Then, he would more and more deeply diverge until we had spent a significant portion of the lecture listening to "war stories".

Although, some of these stories might have helped we students to understand the horror of war, in reality, we had no idea what he was talking about most of the time. It was just a habitual digression that neither had any relevance nor taught us any life lessons.

- Do ask for student's inputs. As with other techniques, it is recommended that teachers occasionally ask for student feedback. I ask at least once/semester if the stories are helping. As I mentioned in the abstract, the students almost always appreciate the stories and ask for more. The only way one knows is through asking.

- Don't begin a story with "I was so drunk once that I ...". While stories about our personal lives are often relevant, there are places where we just should not go. A teacher must remember to keep a professional distance from the students at all times and not discuss stories that are inappropriately personal.
- Do be sincere. Telling stories from the heart are OK. Every semester, I tell my students how I met my wife (at the Cincinnati airport). This is a wonderful, sappy story about a random occurrence leading to a lifetime commitment. The students (both men and women) love the story.

Student Feedback

I have scores of feedback from students regarding story-telling in the classroom. In my current offering (winter semester, 2006) of Software Engineering, I asked for mid-semester feedback to the following question: "What aspects should remain in the course for the second half of the semester?" Without prompting, ten out of fifteen students had replies such as:

- "Amusing" anecdotes,
- Interesting, tangentially related topics,
- Real-life examples and stories,
- Sense of humor (presumably partially shown through stories),
- Funny stories (more of them!).

Summary

Story-telling is another tool that should be in the repertoire of every college faculty. Along with many other teaching techniques, story-telling can make a richer, more interesting environment for teaching and learning. As mentioned, story-telling may be used effectively to illustrate important points, give coherent meaning to seemingly divergent topics, aid students in remembering content, or simply to break up a long lecture.

Often, faculty fear techniques that we interpret as divergent from the core course material. However, story-telling can often be used to complement, rather than detract from, the course content that we are attempting to communicate to the students.

When you have time, ask me about 'The Legend of the Pink Pearl'. It is a very good story!

References

[1] Singh, S. The Code Book: The Evolution of Secrecy from Mary, Queen of Scots to Quantum Cryptography. Doubleday Publisher, 1999.

[2] Wingfield, R. Narration of the Last Days of the Queen of Scots.

[3] Felder, R., and Brent, R. Effective Teaching: A Workshop. University of Michigan, Ann Arbor, MI, 10-11 March, 2000.

[4] Durant, R. You Mean the World to Me: Story Telling and Leader Listening in Organizational Learning. Ph.D. Dissertation, The University of Alabama, 2002.