AC 2010-258: BIG FISH III: BUT, DOES STORY-TELLING WORK?

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Big Fish III: But, Does Story-Telling Work?

Abstract

At the American Society of Engineering Educators (ASEE) Conference in Chicago, Illinois during June, 2006, the author presented a paper on the lost art of story-telling[1]. The 2006 paper focused on *when* story-telling might be effectively used in the classroom, such as to illustrate important points, give coherent meaning to seemingly divergent topics, aid students in remembering content, or simply to break up a long lecture. In June, 2007, at the ASEE Conference in Honolulu, Hawaii, the author presented a paper on *how* to tell stories in the classroom[2]. The 2007 ASEE paper first discussed some basic skills and approaches for story-telling. The 2007 paper discussed the two important skills of remembering a story worthy of telling, then telling the story worthy of remembering.

This paper is very likely the final paper in the trilogy. (Otherwise, it would not be a trilogy!)

Data was collected regarding the quantity and sequential proximity of stories and content in an engineering classroom in an attempt to draw conclusions about its effectiveness as a teaching method. Specifically, data was recorded about the quantity of time used for story-telling by faculty during a semester-long course, the proximity between stories and course content, and the performance of students on exams. Finally, a subset of students in the course kept logbooks that reflected on their thoughts regarding story-telling in the classroom.

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. This paper will present preliminary results about whether story-telling helps students to learn.

Introduction

Story-telling is an age-old technique for conveying information, teaching a moral lesson, or simply entertaining. It has a prehistoric basis, in that early knowledge was transmitted from person to person via the oral tradition prior to most people being literate. Story-telling is entertaining to children; and is very likely still entertaining for adults, when someone tells a convincing or entertaining story.

For educators, there is a wide array of technology to assist in communicating the course material to the students. Although the author is an advocate of new technology, he acknowledges that sometimes educators confuse the use of new technology in the classroom with enhanced learning by our students.

As an example, a typical classroom at the University of Michigan is equipped with an LCD projector, overhead projector, document camera, chalkboards or whiteboards, wired speakers, and sometimes video capture. Students are becoming more technically sophisticated as well. One can generally assume that each student has a cell phone of some form, mp3 player (or

equivalent), and many / most students now bring laptop computers to the classroom. Many instructors teach from a chalk-and-talk, but many also have some form of laptop used in the classroom such as a tablet PC.

The goal of the three papers on story-telling is simply to remind us, as engineering educators, that sometimes simple, time-tested teaching methods still work well. The first paper[1] focused on *when* story-telling might be effectively used in the classroom, such as 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 second paper[2] discussed *how* to tell stories in the classroom. That is, the paper discussed the two important skills of remembering a story worthy of telling, then telling the story so that it is worthy of remembering.

This paper will present preliminary results about whether story-telling helps students to learn. Data was collected regarding the quantity and sequential proximity of stories and course content in an engineering course in an attempt to draw conclusions about the effectiveness of story-telling as a teaching method. Specifically, data was recorded about the quantity of time used for story-telling by faculty during a semester-long course, the proximity of story-telling to course content, and student performance on exams covering course content that occurred in proximity to stories told during lectures. Finally, a subset of students in the course kept logbooks and reflected on their experience with story-telling in the classroom.

This paper is organized as follows. The following section describes the method for gathering data for this research is described. The subsequent sections describe the results of the data, and attempt to gather meaningful conclusions from the data. Finally, the paper is summarized.

Method and Form of Data Gathering

The course that was analyzed for this research was a sophomore / junior level computer science course, entitled Data Structures and Algorithms. There were initially ~150 students enrolled, with 144 students finishing the course. The course met twice per week for 80 minute lectures, and had an additional discussion section for 60 minutes per week. The data was collected during the lecture sections delivered by the course faculty, but not during the discussion sections delivered by the teaching assistants.

Three major sources of data were used for analysis in this paper. The first two were quantitative in nature, and the third source was qualitative. All are described below.

Each 80-minute lecture was audio recorded by a research assistant using either a digital audio recorder, or a Livescribe Pulse Smartpen ©. A Smartpen is a pen with a built-in digital audio recorder. The pen records audio and associates it with notes that the student is taking. After the lecture, the student can touch locations on the page, and the Smartpen plays back the audio that was recorded at that time.

Using both methods of audio recording, a research assistant attended and recorded each lecture. After the lecture, the research assistant would review the lecture and populate the following fields in a table:

- Date;
- Story Topic: brief description of story;
- Story Type, defined as:
  - 1: directly tied to course material;
  - 2: not directly tied to course material, but some implicit or explicit moral lesson;
  - 3: just a story to break up a long lecture.
- Material Preceding Story: course content that was covered just prior to story;
- Material Following Story: course content that was covered just after story;
- Who Told: the course was co-taught by two faculty, so we wanted to record which faculty taught which lecture;
- Time: when in class period story was told, including start and end time;
- Duration: duration, in minutes for each story.

As an example, the first few entries in the table are as follows:

Date	Story topic	Story type	Material preceding story	Material following story	Who Told	Time	Duration
13JA09	Wife on fire while setting up Xmas decorations	3	N/A (beginning of class)	Definitions of data structures and algorithms, run times for linear/binary search	DC	3:12 - 3:15	3 minutes
13JA09	Euchre - didn't alphabetize list of players because only 6 of them	2	Typical approach to algorithm selection	Analysis of algorithms (dinner at home example)	DW	3:22 - 3:23	<1 minute

Table 1. Sample data from log recording stories that were told.

For comparison, data was kept on both the midterm and final exam. Specifically, the following fields were populated:

- Avg Score: average score on exam question by students taking the exam;
- Difficulty: difficulty of the question as determined by course staff, with 1 being easiest and 5 being hardest;
- Story Type 1: binary (0 or 1) about whether a story of type 1 (story was directly tied to course material) was told either just before or just after related material during lecture;
- Story Type 2: binary (0 or 1) about whether a story of type 2 (not directly tied to course material, but some implicit or explicit moral lesson) was told either just before or just after related material during lecture;
- Story Type 3: binary (0 or 1) about whether a story of type 3 (just a story to break up a long lecture) was told either just before or just after related material during lecture.

In other words, the last three fields indicate whether or not a story was told in proximity to the material that was tested on the exam.

Finally, a subset of students in the course kept journals that reflected on the stories that were told in the classroom. The students volunteered to participate in the study, with a clear indication that participation (or non-participation) would have no reflection upon their grade in the course.

The research was part of an Investigating Student Learning (ISL) grant at the Center for Research on Learning and Teaching (CRLT) at the University of Michigan. Recipients of the ISL grant were given a general exemption to obtaining individual IRB approval. It should be noted that all research in this paper met with Institutional Review Board (IRB) approval. Specifically, students were informed of, and signed a consent form indicating that:

- Participation in the research had no bearing on the student's grade;
- All student identifiers were removed;
- All work was kept locked;
- Qualitative journals were destroyed after the research was completed.

Sixteen students initially volunteered to keep reflective logbooks. Of those, 10 students turned in the logbooks at the end of the semester, and six or seven made meaningful entries throughout the semester. Small incentives (T-shirts, coffee mugs, etc.) were used to motivate students to initially participate, then to actively continue participation throughout the semester.

Specifically, students were asked to reflect weekly as follows:

> "Please follow the given guidelines related to your journal entries. Sometime between Saturday when you wake up, and Sunday when you go to bed, please do the following:
>
> - Spend no more than 30 minutes answering the questions (15 minutes should be adequate);
> - Responses each week should be no more than 1-2 pages;
> - Keep your class notes and textbook closed while journaling. No fair peeking!;
> - The depth of your response is your choice. However, this exercise is not meant to be an in-depth review of all material from the class;
> - Journaling should discuss both Tuesday and Thursday lectures.
>
> Please respond (each week) to the following questions:
>
> 1. What do you remember from the Tues and Thurs lectures?
> 2. What course content did you learn?
> 3. Did any stories that were told in class help you to learn and retain what was taught in class? If so, which stories?"

The log books were collected occasionally (three times throughout the semester) to determine compliance with the above guidelines. Students sometimes needed to be 'coached' to respond as requested. That is, as the semester wore on and / or significant project or homework assignments were looming, students needed to be encouraged to continue responding weekly to the questions indicated above.

There were two faculty teaching the course, who would alternate delivering lectures. Although the other faculty was not actively involved in this research, he participated wholly. In some cases, data analysis involves only one or the other faculty, but in most cases, data from both of

our lectures is analyzed. As examples, data analysis regarding how many stories were told, and of what type, was discriminated between faculty. However, analysis of student performance on exam data was not.

Data Set 1: Quantity and Proximity of Stories to Course Material

Table 2 is a summary of all stories told throughout the semester. So, as an example, the author told 30 stories over the course of the semester. One of the stories was of type 1 (directly related to course material), thirteen of the stories were of type 2 (had some implicit or explicit moral lesson), and sixteen of the stories were of type 3 (used to break up lecture). Continuing to the next column, nine stories were told during the first 15 minutes of class, typically as a warm-up or transition to the lecture. Twenty stories were told in the core of the lecture, and only one story was told in the last fifteen minutes of lecture. Finally, approximately 50 minutes was used by the author for story-telling throughout the semester.

	Number of Stories	Story Type	When During Class Period	Time Spent
Author	30	1:1 2:13 3:16	1st 15: 9 Core: 20 Last 15: 1	49.5 minutes
Co-Faculty	17	1:7 2:6 3:4	1st 15: 5 Core: 11 Last 15: 1	24.25 minutes
Total	47	1:8 2:19 3:20	1st 15: 14 Core: 31 Last 15: 2	73.75 minutes

Table 2. Stories told throughout the semester.

The next table normalizes the number of stories by the amount of lectures. In other words, the author gave more lectures than co-faculty, so the table summarizes on a per lecture basis. In summary, the author told about 3 stories per lecture using about 5 minutes of lecture time. Co-faculty, told about 2 stories per lecture using about 3 minutes of lecture time. On average, we used about 4 minutes of lecture time each day over the course of the semester.

	Number of Stories/Lecture	Time Spent
Author	30/10 = 3	~5 minutes
Co-Faculty	17/8 = 2.125	~3 minutes
Total	47/18=2.61	~4.1 minutes

Table 3. Data from Table 2 normalized to amount of lectures.

The following table summarizes the amount of time in each lecture spent by the author telling stories. We were looking for trends from beginning to end of semester, such as "Were more stories told earlier in the semester than later?" No significant trends were found.

Lect1	Lect2	Lect3	Lect4	Lect5	Lect6	Lect7	Lect8	Lect9	Lect10
10	5.5	6	3	5	3	7	1.5	7	1.5

Table 4. Time spent by author telling stories per lecture.

Similarly, the following table summarizes the data for co-faculty. Again, no significant trends were found.

Lect1	Lect2	Lect3	Lect4	Lect5	Lect6	Lect7	Lect8
4.5	1	4	6	4.5	3	.25	1

Table 5. Time spent by co-faculty telling stories per lecture.

As importantly, data was kept about what course material was discussed just before a story was told and just after a story was told. So as an example, data that was collected showed the following sequence:

- Lecture material on pseudo-code syntax;
- Story on algorithmic efficiency being programming language independent;
- Lecture material on principles of algorithmic analysis.

This sequential information was later used to determine the sequence of a story relative to course material, and student performance on exams based upon said proximity.

Data Set 2: Student Performance Relative to Stories

A regression analysis was performed on the data using Minitab statistical modeling software. The average student score on each exam question (midterm and final) was used as the dependent variable. The independent variables were question difficulty and a set of binary variables representing whether or not a story of each type (1, 2, or 3) was told immediately before or after the topic of the question.

The means for evaluating student performance relative to stories was based on average student performance on the midterm and final examinations. Each exam question was inspected after the exam was administered to determine if it matched a topic listed in the data table discussed earlier (see "Method of Data Gathering"). That is, exam questions were not explicitly written to match the stories that were told, but were written and later examined to determine if there was any type of match. If so, the binary variable for the particular story type told, either before or after that question topic, was set to 1. Otherwise, the binary variable was set to 0. If no story was told either before or after the question topic, all binary variables were set to 0.

Upon review of the exam, the difficulty level variable was set by the course instructor for each exam question. The scale was from one to five, with one being the easiest and five being the most difficult. There was at least one question of each difficulty level (one through five) on each exam. The raw data for the midterm exam is captured in Table 6, and for the final exam in Table 7.

↓	C1	C2	C3	C4	C5	C6
	Question	Avg Score	Difficulty	Story Type 1	Story Type 2	Story Type 3
1	1	8.50	1	0	0	0
2	2	5.08	3	0	0	0
3	3	3.70	5	0	0	0
4	4	4.77	4	0	1	0
5	5	9.07	2	0	1	0
6	6	6.23	1	0	0	1
7	7	6.75	2	0	0	0
8	8	6.30	3	1	0	0
9	9	7.65	3	0	1	0

Table 6. Raw data from midterm exam.

↓	C1	C2	C3	C4	C5	C6
	Question	Avg Score	Difficulty	Story Type 1	Story Type 2	Story Type 3
1	1	8.7	1	0	0	0
2	2	6.8	3	0	0	0
3	3	3.3	5	0	0	1
4	4	7.4	3	0	1	0
5	5	5.4	3	0	0	1
6	6	6.7	3	0	0	1
7	7	5.5	4	0	0	0
8	8	7.8	1	0	0	1
9	9	7.8	1	0	0	1
10	10	7.2	2	0	0	0

Table 7. Raw data from final exam.

The tabular results of the Minitab regression analysis are shown in Figure 1 (for the mid-term exam) and Figure 2 (for the final exam). The analysis of the data focuses on the regression equation, 'Coef' (aka coefficient), and 'p' (aka p-value) columns.

As can be seen, the regression equation derived from the data from the midterm exam is:

9.75 – 1.36 Difficulty + 0.633 Story Type 1 + 1.50 Story Type 2 – 2.16 Story Type 3

With p-values of: p(constant) = 0.0; p(Difficulty) = 0.005; p(Story Type 1) = 0.522; p(Story Type 2) = 0.073; and p(Story Type 3) = 0.097.

For the final exam, the regression equation is:

9.70 – 1.06 Difficulty + 0.881 Story Type 2 – 0.744 Story Type 3

With p-values of: p(constant) = 0.0; p(Difficulty) = 0.0; p(Story Type 2) = 0.152; and p(Story Type 3) = 0.059.

Regression Analysis: Avg Score versus Difficulty, Story Type 1, ...

The regression equation is
Avg Score = 9.75 - 1.36 Difficulty + 0.633 Story Type 1 + 1.50 Story Type 2
- 2.16 Story Type 3

Predictor	Coef	SE Coef	T	P
Constant	9.7533	0.7879	12.38	0.000
Difficulty	-1.3621	0.2461	-5.53	0.005
Story Type 1	0.6330	0.9043	0.70	0.522
Story Type 2	1.4964	0.6194	2.42	0.073
Story Type 3	-2.1612	0.9997	-2.16	0.097

S = 0.806922 R-Sq = 89.6% R-Sq(adj) = 79.1%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	22.3251	5.5813	8.57	0.030
Residual Error	4	2.6045	0.6511		
Total	8	24.9296			

Source	DF	Seq SS
Difficulty	1	13.5241
Story Type 1	1	0.0358
Story Type 2	1	5.7222
Story Type 3	1	3.0430

Figure 1: Regression analysis for the midterm exam.

Regression Analysis: Avg Score versus Difficulty, Story Type 1, ...

* Story Type 1 has all values = 0
* Story Type 1 has been removed from the equation.

The regression equation is
Avg Score = 9.70 - 1.06 Difficulty + 0.881 Story Type 2 - 0.744 Story Type 3

Predictor	Coef	SE Coef	T	P
Constant	9.7043	0.3808	25.49	0.000
Difficulty	-1.0617	0.1186	-8.95	0.000
Story Type 2	0.8809	0.5372	1.64	0.152
Story Type 3	-0.7438	0.3206	-2.32	0.059

S = 0.477541 R-Sq = 93.7% R-Sq(adj) = 90.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	20.4757	6.8252	29.93	0.001
Residual Error	6	1.3683	0.2280		
Total	9	21.8440			

Source	DF	Seq SS
Difficulty	1	17.7466
Story Type 2	1	1.5013
Story Type 3	1	1.2278

Figure 2: Regression analysis for the final exam.

A p-value less than 0.05 (5% false positive rate) is often considered to be statistically significant. Therefore, despite the fact that the overall regression shows statistical significance, components of the regression model are only considered statistically significant if they also possess p-values below 0.05. For both exams, this applies only to the constant term and the difficulty term, **not** any of the story type terms.

However, for the purposes of additional analysis the significance threshold is relaxed to 0.10 (a 10% false positive rate). In this case, the contributions of Type 2 and 3 stories become statistically significant for the midterm exam, and the contribution of Type 3 stories are significant for the final exam as well. Now, the contribution of these variables to the exam scores is examined. This is measured by the coefficient for the corresponding variable in each regression equation. For both exams, the coefficient for Type 3 stories is negative, meaning that having a Type 3 story told immediately before or after an exam topic actually hurts exam performance. On the contrary, the coefficient of Type 2 stories for the midterm exam is positive, meaning that, on average, Type 2 stories improved midterm exam performance. (Note: Type 1 and 2 stories also had positive coefficients in the cases when they were not statistically significant.) This data might generally suggest that Type 1 and 2 stories improve exam performance, while Type 3 stories may in fact hurt student exam performance.

Note that, before concluding that Type 3 stories consistently detract from student performance, a qualitative argument is proposed later in the paper in the discussion of Data Set 3.

Since the difficulty term is statistically significant, its coefficient in the regression model was examined. In both cases, the coefficient was less than zero (negative). This means that a higher value for the difficulty variable corresponds to a lower average score. This seems intuitive, since higher values for difficulty correspond to more difficult questions.

To reiterate, we cannot conclude from this data set alone that stories of any type either help or hurt student understanding of topics, as represented by exam scores. However, the data certainly suggests the possibility that Type 1 and 2 stories may improve student exam performance, while Type 3 stories may actually hurt student exam performance. A greater sample size could help give greater insight into this issue. For example, only one exam question related to a Type 1 story was used on both exams combined, so not much data about Type 1 stories could be collected. Continuing the research with future semesters of similar courses and/or using homework scores as supplementary data points could aid in further validation on this research topic.

Data Set 3: Student Reflection

The final data set contains qualitative responses from students as recorded in a semester-long, reflective logbook. Please recall that students were asked to respond to the following questions:

1. What do you remember from the Tues and Thurs lectures?
2. What course content did you learn?
3. Did any stories that were told in class help you to learn and retain what was taught in class? If so, which stories?

Comments from the students are summarized below. But first, they are broadly categorized as follows:

- Visual Thinkers: stories helped students understand course material through visualization;
- Deeply Reflective: students thought deeply about stories, and wrote extensively about effect of stories;
- Remembered both course material and stories, and related them to each other;
- Remembered course material, but not stories: during weekly reflection, no medium-term memory of stories, but 'reasonable' memory of course material;
- Remembered stories, but not course material: opposite of above;
- Remembered emotion evoked (humor) from stories: no distinctive memory of stories or course content, but remembered that a story (or two) was told.

Note that there is some overlap in students' interpretation and memory of stories using the categories listed above.

Visual Thinkers

"This week in class we talked about a more specific type of tree, namely AVL search trees. We discussed what makes a tree an AVL tree, and how to "fix" an AVL tree that is unbalanced by rotating various nodes right or left. Being a visual learner, the graphical slides showing how the left and right rotations worked were the most helpful. I unfortunately don't remember any stories."
"…By listening to material-related stories, it helps me to come with my own story and remember the material forever"
"… but demonstrations (interpretive dance) really help me to visualize what each element (or student) is doing."
"No stories come to mind, but the demonstrations with people on the stage were helpful."
"The only one (story) that I can think of is not really a story but the heap sort demo on stage made sense and helped clarify a lot."

Deeply Reflective

"The difficulty to understand those algorithms lies in the abstraction of the methods. However, with the illustration of Dr. Chesney, we transformed something abstract into a concrete process of sorting the students… This week's content was difficult. But now I find them easy to understand. Taking 281 lectures is not only for study, but also for fun. I believe most students think so, too, because there is laughter and applause from time to time throughout the classroom."
"Dr. Chesney started his lecture in a unique way: he drew his family tree on the blackboard for us. He told us the story of his family's immigration to the USA. Before I came to the USA, I did hear that USA is a 'country of immigrants.' Dr. Chesney's story reminded me of many friends that I've met here, who are also immigrants."

Remembered Course Material and Stories

"Dr. Chesney told a story about a guy lost outside his house and how he gave him useless information that was factual. He then related that to saying everything is $O(2^n)$. True, but useless."
"I love the story about the family tree. Family tree is an excellent example of trees. It explains the component of the tree thoroughly, and the most interesting things (I'm 100% sure now that terms of tree originate from family tree). The terms 'children, parents, siblings, ancestor' match the common sense of family trees."
"Not really a story, but the phonebook analogy helped explain the difference between two search algorithms."
"We did a lot of work with airport examples – Professor's "How I met my wife" story may help us to remember examples."

Remembered Course Material, but Not Stories

"We went over trees, BST's I think. Was there a story? Did Chesney tell us a story about ___? I forget."
"…I do not remember a story, probably because it was completely unrelated."

Remembered Stories, but Not Course Material

"Dr. Chesney told us the story of how he learned to blade shave and became a full time professor."

Remembered Emotions Evoked

"Again, Dr. Chesney told a funny story, I couldn't recall, but he kept my attention during class."
"Story at some point. It was hilarious. Don't remember though."
"The story keeps me in a state of curiosity and excitement, and it keeps me from falling asleep ☺."
"I don't know if the stories themselves help to learn the material, but they make class more tolerable."

Summary

In most pedagogical research, the academic researcher hopes to conclusively show that the method being advocated somehow improves the learning and teaching experience. That was certainly the hope with this research. However, from the data analyzed thus far, the following conclusions may be drawn.

In general, the author told more stories, both in terms of time per class and quantity of stories, than his co-faculty. The stories that were told often had a deeper moral lesson, but often were irrelevant stories used to break up an 80 minute lecture. On average, we used an average of 4 minutes per class period telling stories.

It is very difficult to derive stories that are closely tied to course material. Based upon the data gathered and analyzed, proximity of a story to course content had an apparent influence on student performance on exams. Course-related stories and stories with some explicit moral lesson likely improved student exam performance, while stories used only to break up a long lecture detracted from student performance. However, difficulty as perceived by course staff, influenced performance on exams. Or simply stated, students scored lower on more difficult questions.

Students, qualitatively, did enjoy stories in the classroom. Some students saw a direct tie-in with course material. Some sets of students remembered the specifics of stories. Finally, some students did not remember the details of the stories, but thought that stories gave a needed intellectual break during lecture.

In conclusion, this paper offers an interesting, yet statistically unconvincing case for the use of story-telling in the engineering classroom. Qualitatively, students reflected that they thoroughly enjoyed stories in the classroom both to help retain course content, and also as a mental break from the difficulty of an 80-minute lecture.

As educators, we know that the attention span of our students is approximately 15-20 minutes. We need an array of tools and methods to re-gain the attention of our students after such a time interval. The author remains convinced that story-telling is one such viable teaching method for engineering educators.

Future Work

Possible future work includes:

- Complete a learning style inventory and then track their preferences / learning with stories with respect to those learning styles;
- Increase the sample size of the analysis, particularly related to Type 1 (direct course related) stories;
- Assess long-term retention of course material (and perhaps stories) after a longer period of time, say one year.

The Story Continues

Heh, did I tell you about how my boat was tied up to a dock in the Manistee River and I was woken up in the middle of the night because we were about to be crushed by a lake freighter? Well, I …

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