

# Story Telling and Visualizations with Data

## An Alternative Entry Point to Computer Science Education

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**Abstract – The supply of professionals trained in Information technology is not able to meet the demands for these positions in the workforce. Several strategies are being developed and used by academia and industry to meet this demand. To attract a broader audience the researcher in this paper presents experimental results from using a set of story telling and visualization tools in K12 classrooms. These tools allow the opportunity to teach CS related topics to students in an engaging manner that motivates them to pursue CS /IT as an academic choice.**

**Keywords-Story telling, Data Visualization, Computer science education, computer graphics, high school students**

### I. INTRODUCTION

“Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child’s analytical ability” [1]. To achieve this goal, several non-traditional and engaging approaches such as game development, mobile app development, robotics etc. have been developed and implemented successfully to teach computer science concepts. However these approaches do not seem to be enough to recruit enough students to meet the demands of the IT workforce.

### II. APPROACH

The researcher in this paper presents another approach (Story telling and Visualizations with Data and Computer Graphics) to entice and cultivate an interest among high school students to pursue CS and IT fields of study. Visualizations have been known to be effective tools in communicating abstract ideas in all branches of science including, CS, mathematics and Physics [2], [3] [4]. The existing body of research and guidelines from ACM provided the impetus for experimenting with these new techniques to introduce students to fields of computational thinking. ACM recommends the use of computer graphics and visualizations as core topics to be included in the body of computer science knowledge and states that

“Computer graphics depends on an understanding of how humans use vision to perceive information and how information can be rendered on a display device.

Every computer scientist should have some understanding of where and how graphics can be appropriately applied as well as the fundamental processes involved in display rendering” Similarly, visualizations seeks to determine and present underlying correlated structures and relationships in data sets from a wide variety of application areas. The prime objective of the presentation should be to communicate the information in a dataset so as to enhance understanding”

The audience in this case was 20 high school (10<sup>th</sup> grade) students who were enrolled in an information technology course. They meet twice a week for fifty minutes each class period. Their normal course work includes introductory java programming. However it was noticed that the students were not engaged in this course but were taking it since it was a required course. The school representative and the researcher met to discuss the possibility of using story telling and visualizations with data and computer graphics as a vehicle to motivate students to engage with computational disciplines and pursue it in their higher education.

### III. CHOICE OF TOOLS

Current research suggests that many high school students and college students are “intrigued by artistic and scientific problems in computer graphics” [5], Similarly from the researcher’s experience, story telling with data, and the notion of Big data (students really did not know what it meant, they simply heard about it and thought it was cool) was another interesting area that students seem to like. However, research also suggests that the attention span for high school students is limited and hence it was essential that the tools chosen for the experiment had to be such that they yielded quick results, suitable for people with not much of a background in programming or statistics and had a small learning curve. Upon completing a brief survey on tools available for teaching data visualizations and computer graphics we found that Tableau and Processing were two choices, which could be used for this purpose. Tableau and processing are both open source software tools, and work on both windows and mac platforms thus catering to all users. Processing was also used in undergraduate courses and reported successful student learning outcomes [6].

Additionally they also seem to fit in with the guidelines from ACM that the using the processing software students can quickly learn how to render graphics to a display panel (monitor) and use Tableau to visually convey the results from a data set and provide a narrative to describe their findings.

#### IV. IMPLEMENTATION PHASE

The researcher volunteered at the school and visited the class twice a week for fifty minutes each class period, for a total of six weeks. Four class periods were spent on simple data mining concepts such as the association rule and data visualizations with Tableau software.

##### A. Data Visualizations and Data Mining Concepts

Research suggests that student engagement is crucial in the learning process for students to successfully obtain the learning outcomes for any given topic. In this case, the learning outcome was for students to recognize that there are software techniques available which can help us in decision-making related to activities that occur in daily life. Without these tools, the decision making process could not be as effective. The following example was used to drive home the use of an association rule in planning to setup a grocery store in a neighborhood and at the same time engage them in the activity. The association rule was chosen for simplicity. Since these were 9th and 10th grade students, we simplified the rule and explained it in a broad manner to communicate the main idea of the rule.

All the students were asked to list out the items they normally eat for breakfast, and students listed out cereal, fruit, milk, toast, pancakes, waffles, eggs, and even pizza. Students were then asked to construct a table, manually listing out what each of them had for breakfast. The table below is a result of the exercise with values from 10 students, the number 1 signifying that they ate that specific item and 0 specifying that they did not eat that item. For simplicity we did not include jam, jelly, butter, maple syrup etc. in this list.

TABLE I. ENTRIES FOR BREAKFAST

Student	Breakfast Items Listed					
	Cereal	Toast	Milk	Waffle	Eggs	Pizza
St 1	1	0	1	0	0	0
St 2	0	1	0	0	1	0
St 3	0	1	0	0	1	0
St 4	0	0	1	1	0	0
St 5	1	0	1	0	0	0
St 6	0	0	0	0	0	1
St 7	1	0	1	0	0	0
St 8	1	0	1	0	0	0
St 9	1	1	1	0	0	0
St 10	1	0	1	1	0	0

Students were then asked to find associations of items and the corresponding number of instances in this table and list them manually.

The findings were as follows

- Cereal and milk – 6 instances
- Toast and eggs – 2 instances
- Toast and milk – 1 instance
- Waffle and milk – 1
- Toast and milk – 1
- Pizza – 1
- Cereal, toast and milk - 1

Students were then asked to describe what they saw in this table. Their observations were very predictable; they found that cereal and milk occurred together most frequently, that there was an association or a relationship between these two items, suggesting that it was a popular choice for breakfast. Similarly, the second frequent occurrence was toast and eggs, followed by 1 instance for toast and milk, waffle, milk, and cereal, toast and milk. However, pizza was a lone item, it did not associate with anything else.

When students were asked to suggest what they would like to stock up in their fictitious grocery store, all of them mentioned that milk and cereal were their first choice and then depending on the space available they would stock up bread, eggs, waffles, and pizza in that order. They recognized that such an arrangement in a tabular format quickly enables them to visualize the associations between various items and helps them in making educated decisions.

Later, the instructor informed students about data mining and how software tools such as Excel, SPSS, Weka have built-in functions which can take huge data sets and perform the analysis and provide output that can then be used by individuals to plan marketing, forecast stocks etc. These tools can also provide the degree of confidence for each of the outcomes and hence it becomes a stronger claim.

##### B. Tableau

Students then began to use Tableau for interactive data visualizations, which research suggests allow for active learning [7], [8]. The interactive nature of Tableau was well suited for this audience as students could manipulate the variables and observe the effects, they could also place their mouse over different parts of the charts and notice the corresponding data values for those points which demonstrated the connection between the visual and the actual data values. Students obtained various data sets, which were sizeable from the Internet and experimented with various available options in Tableau. This activity primarily addressed the use of dependent and independent variables, and communication skills. Students were asked to choose a dataset, describe the questions they wanted to explore and use different visualization tools in

Tableau and choose the tool that best described their data set. Students explored using bubble charts, interactive maps, bar charts, pie charts, etc. and provided their rationale for the choices they made. Example screen shots from student work are presented below. Figure 1 is a dashboard related to sports and the salary paid for each position in a baseball game

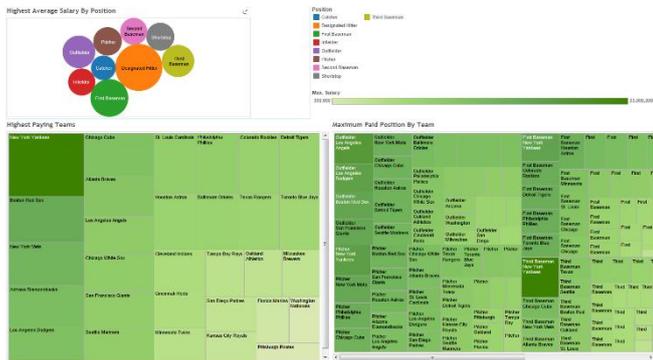


Figure 1. Dashboard on Sports and Salaries

Figure 2 is an example screen shot from data related to the number of medals won by each country since the Olympic games have started.

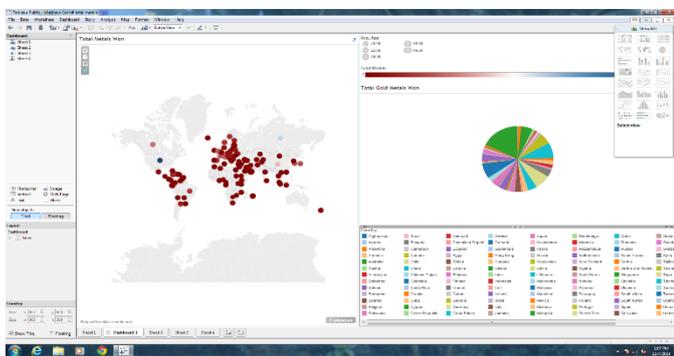


Figure 2. Olympic Medals per Country

C. Learning outcomes from these activities

Be able to observe and describe association between two instances, as in the case of Milk and Cereal by manual counting.

Be able to recognize the need for software packages to analyze big data sets

Be able to analyze and interpret results from Tableau dashboards and make presentations. Students were in fact asked to treat it as a story and were encouraged to describe their activities in Tableau as a story by including the following:

What is it that they want to do with the data?

What do they want to find?

Did they succeed in finding what they were searching for?

What do the findings mean? Students

Many students found this informal structure to be a friendly format for them to describe their projects in Tableau. Several students also liked Tableau and used it in their other courses such as Business Foundations (also a required course in 10<sup>th</sup> and 11<sup>th</sup> grades) for their class projects. This indicates that students achieved deeper learning since they were able to practice the skill of transference of knowledge from one discipline / situation to another new situation.

D. Computer Graphics and Visualizations

Research also suggests that computer graphics, animations are a very attractive recruitment strategy used by many institutions to recruit students into IT and CS disciplines [9]. Additionally, graphics, and animations are also an effective teaching strategy for Computer Science topics [10]. We used the Processing programming language, a very easy to use software package to introduce students to computer programming. Unlike Photoshop, flash, paint or other software packages where students do not write any code but use the tools to compose their graphics, Processing requires students to write the code to generate graphics on the screen.

The coordinate plane served as the foundation to introduce the concept of canvas and pixels on the computer screen. Figure 3 is the example graph sheet used to introduce drawing shapes on a coordinate plane which would then be used in the code segments as shown in code segment 1. Figure 4 is the visual display of code segment 1, in Processing. We implemented the following process to introduce computer graphics to 10<sup>th</sup> grade students.

- Students first practiced drawing several shapes (ellipse, rectangle, triangle, hexagon etc.) and plot their corresponding x,y coordinates on a graph paper.
- Students were then taught basic use of variables and built-in functions for shapes in Processing language. Students quickly learned to use code similar to the segments presented below to design their graphics with basic shapes on the screen.

1) Code Segment 1: Draw Basic Shapes.

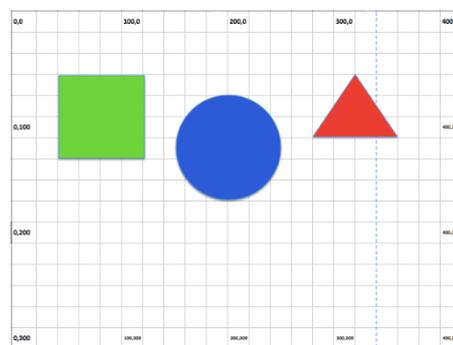


Figure 3. Basic Shapes on Graph Paper

```
“size(400,300);background(0);fill(0,255,0);rect(20,60,80,80);fill(0,0,255);ellipse(200,120,100,100);fill(255,0,0);triangle(320,60,280,120,360,120);”
```

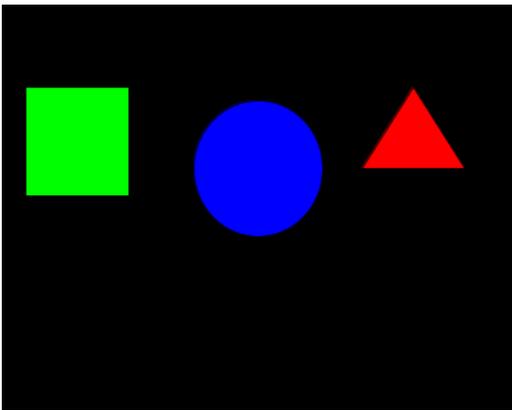


Figure 4. Output of translation of the graph paper exercise to code

From here, students were given time to design their own graphics, combining different shapes. By the second week of learning processing, students were able to generate composite graphics in Processing. Code segments 2 and 3, are student generated code resulting in composite graphics resulting in figures 5 and 6.

### 2) Code Segment 2: Sun Flower.

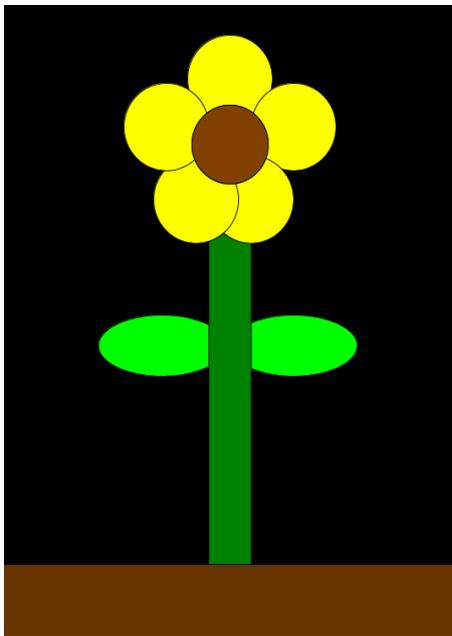


Figure 5. Sunflower

```
“rectMode(CENTER);size(600, 800);background(0);fill(0, 255, 0);ellipse(220, 450, 150, 70);fill(0, 255, 0);ellipse(375, 450, 150, 70);fill(0, 129, 0);rect(300, 500, 50, 500);fill(255, 255, 0);ellipse(300, 145, 100, 100);fill(255, 255, 0);ellipse(375, 200, 100, 100); fill(255, 255, 0); ellipse(325, 283, 100, 100);fill(255, 255, 0);ellipse(260, 283, 100, 100);fill(255, 255, 0);ellipse(225, 200, 100, 100);fill(0, 255, 255);ellipse(300, 220, 90, 90);fill(129, 64, 0);ellipse(300, 220, 90, 90);fill(104, 52, 0);rect(300, 900, 600, 400);”
```

### 3) Code Segment 3: Robot.

```
“voidsetup(){size(500,500);background(255);smooth();drawRobot();}voiddrawRobot(){noStroke();fill(40,38,200);rect(20, 0, 38, 30);rect(14, 32, 50, 50);rect(0, 32, 12, 37);rect(66, 32, 12, 37);rect(22, 84, 16, 50);rect(40, 84, 16, 50);fill(222, 222, 249);ellipse(30, 12, 12, 12);ellipse(47, 12, 12, 12);}”
```

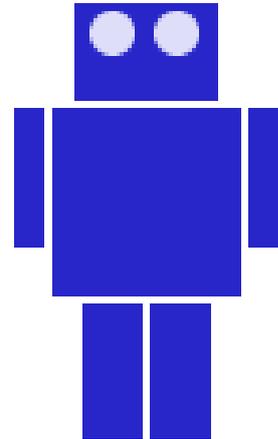


Figure 6. Robot

## V. CONCLUSIONS, FINDINGS, AND DISCUSSION

The six-week activity proved to be productive for the students and the instructor. The students were clearly engaged in this learning environment. The software (both Tableau and Processing) were very easy to use and had a small learning curve so students could quickly write small programs and see the results. Tableau allowed them to feed their data sets into Tableau and create effective visualizations and weave a story that described their data. Some of the student comments after this activity were as follows:

- “I love data mining”
- “Did not know this is how graphics were generated”
- “I would love to present my work at the annual event”
- “I want to learn more programming”
- “I liked Processing more”

The school district is now very interested in this approach and we plan to train the next set of students and present their work at the state level annual event in 2016 and conferences. In the state level annual event, students show case their IT and CS related projects. We hope to get more students enrolled in this project during the next academic year. Other improvements to the content will include more rigor introduced into coding and data analysis by extending the time period from six weeks to 10 weeks.

This activity also suggests that fostering the ability of story telling and visualizations of data through appropriate software tools might be another route that serves as an entry point to recruit students to CS and IT disciplines.

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