Case Study: Bringing Data to Life into an Introductory Statistics Course with GAPMINDER

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1 Introduction

We present findings from our study on using the animation and interactive software, Gapminder, to "Bring Data to Life into an Introductory Statistics Course". Utilizing mixed methods case study, we investigated the benefits of using Gapminder to enhance student learning experience in statistics. Results indicate that Gapminder helps stimulate students' interest and improve their engagement in learning statistics. Gapminder arouses students' natural curiosity about the world development, raises awareness of data, and promotes the use of statistics to understand the world.

In recent decades, statistics has emerged as a separate discipline from mathematics in many universities. It has established itself as a unique field of study, a science that uses mathematics to gain insight from data (Rossman, Chance, and Medina 2006). More and more people are recognizing the growing importance of statistics as its applications have spanned across various disciplines. Consequently, the teaching and learning of statistics has increased dramatically. Statistics instruction has expanded to all educational levels, is gaining more students, and drawing more attention.

Despite the increasing popularity of statistics, research indicates that instructors in introductory statistics courses continue to struggle to stimulate students' interest in the subject. Historically, these courses continue to be "viewed as difficult and unpleasant by many students and frustrating and unrewarding to teach by many instructors" (Garfield, Hogg, Schau, and Whittinghill, 2002). A recent reform movement in statistical education calls on statistics instructors to incorporate more technology and visualization techniques to improve the teaching of statistics, and enhance student's learning experiences (GAISE College Report, 2010).[1]

GAISE suggests that conventional teaching strategies in statistics be supplemented with audio and visual technology to improve students' understanding. Our students today live in the world amass with quantitative data and visual images. It is more vital than ever that people are able to read and interpret visual representations of information. This is particularly true when the audience is the young learners "who have come of age in a technological world where visual information is the norm" (Murphy, 2010). Many studies on statistics reform in the literature offer guidelines and recommendations for improving the teaching of statistics to increase *statistical literacy*. In this study we examine the effectiveness of using the visualization software Gapminder as a tool to bring data to life in the classroom. We aim to promote the use of this innovative tool to assist statistics educators

[1] Recommendations for introductory statistics courses from Guidelines for Assessment and Instruction in Statistics Education (GAISE) project.

in a fun and engaging way. We believe that introductory statistics course should raise students' awareness of data in everyday life and prepare them for a career in today's age of information. Thus, teaching statistical literacy and developing statistical thinking should be the major objective for introductory statistics courses.

Research Problem

Recently more and more open source visualization software have been introduced for exploring multidimensional data: GGobi, Many Eyes, Gapminder, R, etc. However, Gapminder is one of the few that has gained acceptance and popularity due to its free, intuitive, dynamic, and easy-to-use features. Many videos created by Gapminder's co-founder, Hans Rosling, have gained world-wide attention. As users find the instant dynamic and displaying of several dimensional data in Gapminder appealing and attractive, the software's popularity increases exponentially. Many people including teachers and instructors have implemented Gapminder in their presentation to display data about world development collected by the World Bank and other international agencies. *However, what is less understood is how Gapminder can be used to enhance student learning experience in introductory statistics courses. Are there best practices of Gapminder out there on improving the teaching of introductory statistics? Does Gapminder shape their perception and increase their desire to use statistics to understand the world? We will address these issues in this study.*

Research Questions

The purpose of this study is to explore the effectiveness of introducing Gapminder into a beginning statistics course. We have perceived that as the interactive interface of Gapminder makes data exploration and visual analysis interpretation, dynamic, intuitive, and informative, the use of Gapminder will enhance student engagement in the course. We have also predicted that using Gapminder, instructors can capture students' attention, and stimulate their interest in using statistics to understand the social world.

In essence, our study responds to the call from GAISE [2] that promotes teaching more data analysis using real data and less probability emphasizing statistical literacy, developing statistical thinking, and fostering active learning. We address the following research questions:

1. **What are the benefits of using Gapminder in an introductory statistics class?**
2. **In what way does Gapminder help stimulate student interest and engage them in learning statistics?**
3. **What is the relationship between the amount of time students reported spending to complete the project and their interest level in learning and using statistics?**

Research Design

With the approval for exemption for Institutional Review Board, we conducted the study by introducing a course project that involves the use of Gapminder in Statistics 401 D-XW. Statistics 401D-XW which is an introductory statistical methods hybrid course designed primarily for graduate students who are not statistics majors and taking the course either online or on site. The main

[2] Guidelines for Assessment and Instruction in Statistics Education project

objective of the course project is for students to learn to visualize the World Economic and Development Data using Gapminder. Students were to investigate the data sets available in the software to research a topic of interest and create a motion graph to display multiple dimensional data. They particularly learned to identify trends, patterns and relationships among the variables selected. The project was structured to utilize a research framework which includes Planning, Doing, Reporting, and Sharing. Data were collected through two class surveys, discussion data, weekly submission, sample and final videos, written reports/papers, as well as records of grades and demographic information. A mixed methods case study was utilized to take advantage of both types of available data, quantitative and qualitative.

Rationale and Significance of the Study

This case study is significant because it investigated efficacy of using the data visualization software Gapminder in teaching introductory statistics courses. It promoted data awareness and using data to make informed decisions, thus providing motivation for students to want to learn statistics. The results of this study will expand our understanding of the benefits of using visualization software. The richness of the data collected from various sources, surveys, project scores, discussion threads, and email, enabled us to triangulate our findings using mixed methods research. Each source of data complemented each other to enhance our understanding of the studied issues.

2 Literature Review

An ongoing and selective review of literature was conducted to inform this study. Three topics of literature were identified: (1) The Use of Visualization Technology in Teaching and Learning, (2) Literature on Application of Gapminder in Teaching Statistics, and (3) Teaching Statistics Literacy. In conducting the literature review, we put together the web maps to help me track connections among the topics of interest. Figures 1, 2 and 3 illustrate the original web maps for each topic. The goal was to understand the historical context and state of the art relevant to my study of effect of visualization and technology in enhancing students' engagement in learning statistics. In the following sections I have provided the summary from the review of the literature for each topic.

1. Visualization in Teaching and Learning

A large body of literature focuses on the impact of visualization in teaching and learning, especially in teaching mathematics. Research suggests that using visual elements in teaching increases learning outcome. As we are increasingly surrounded with visual images, the emphasis on visual learning strategies and visual technologies continues to gain attention. Various studies on the power of visual learning in secondary mathematics education have been conducted. Visulal learning is defined as "absorbing information from illustrations, photos, diagrams, graphs, symbols, icons and other visual models. It is about making sense of complex information quickly—literally being able to comprehend ideas at a glance" (Murphy, 2003). However, visual learning is not only about acquiring but also communicating information. "The concept of visual literacy, defined as the ability to interpret images as well as to generate images for communicating ideas and concepts" (Stokes, 2005). "We are surrounded by increasingly sophisticated visual images." (Howells, 2003). Consequently, many people would say that their preference learning style is visual. Statistics shows that about 65% of people identify themselves as visual learners and the other 35% are kinaesthetic and

auditory learners. However, very few people learn in just one way and everyone benefits from visual methods. Therefore, visual learning strategies are becoming increasingly powerful tools in teaching and learning, especially in mathematics and statistics. Teachers of statistics face the challenge in teaching quantitative reasoning skills through exploring data, while making theory and data analysis come alive and make them relevant rather than just numbers on spreadsheets. Teachers need to utilize more visualizing techniques and software to help students explore data and learn statistical concepts. However, the use of visuals must be carefully planned to be effective. It should focus on provoking and encouraging thoughtful analysis of the underlying meaning plus the aspects of presentation to excite and entertain learners. "Visualization should help make sense of data that may have seemed previously unintelligible" (Stokes, 2005).

As stated previously, currently, visual technology has become increasingly important in our daily lives. There are few aspects of our daily lives that do not involve a visual component. "Everywhere you look, information is being transmitted visually." (Murphy 2009). In statistics, the focus is not only about interpreting information but also to provide more focus on data visualization. Integrating statistics and visualization enables gaining more clarity during the Exploratory Data Analysis step.

2. Application of Gapminder in Teaching Statistics-Making Data Visual

In order to make introductory statistics courses more effective" educators of statistics have turned their focus on technology. Many statistical software have been developed to assist statistics instructors with up-to-date and real-life data to make presenting data meaningful and interesting. The ultimate goal is to make data come alive and understandable.

Teachers at some schools have begun to use Gapminder to motivate students to use real-life data and visualize trends and changes over time. For example, a high school in New York allows students to get credit for a Global History course by doing a semester-long project using Gapminder. The course **website** is titled **NY iSchool Gapminder**. The purpose is for students to practice skills in data analysis, quantitative reasoning, research process, writing research papers, and public speaking. Another statistics instructor also created a Gapminder Project titled **Gapminder Data Fitting Project** that emphasizes applying advanced analytical via technology. A program in Sweden (birthplace of Gapminder) has started to offer a course for Swedish teachers to learn to use Gapminder in the classroom. In short, more and more educators are starting to utilize Gapminder to further the learning and teaching of their subjects as it is a rich resource that can be applied across the curriculum including math, science, social studies, and language arts.

Conducting this Gapminder study allows us to investigate the benefits of using Gapminder in teaching statistics. We wished to understand how Gapminder could excite students, capture their attention, and stimulate their desire to learn more statistics to understand the social world. Our study will contribute to the literature of visual literacy in statistics. We also focused on the use of other technologies such as Jing, Wiki, YouTube, together with visualization techniques to enhance students' engagement and make learning statistics fun and meaningful. The goal included providing experience exploring large data sets, bringing them to life, and "seeking a meaningful needle in massive haystacks of data" (Smith, 2012).

3. Teaching Statistics Literacy

There is extensive literature on this issue due to the recent activities in a reform movement in teaching statistics. The 2010 GAISE report in 2010 reviewed the survey of statistics teachers and evaluate the progress in teaching statistics. Its evaluation was primarily based on the standards initially set by George Cobb in his 1993 publication, Reconsidering statistics education: A national

science foundation conference.The survey results suggested that more emphasis has been shifted to using technology in teaching. High school teachers make full use of graphing calculators as their main technology in the classroom as well as at home, and in the community. Students can download data to their calculators to perform descriptive and numerical data analysis. College instructors on the other hand, often take advantage of the internet by utilizing statistical software on personal computers. Almost all statistics courses have the lab component where students can apply statistics theories and learn to use software for data analysis.

Besides giving a brief summary of the state of statistics education in this country, the GAISE report also provides many sections that include examples. activities, and projects on using technology. However, the emphasis is still on using software to analyze or simulate, not on visualize data. Figures and graphs provided in the report are mostly tables with a few simple and static black and white graphs. Real data were used but limited to highly processed and old data sets for classroom use rather than updated data. To make teaching statistics more interactive and dynamic. besides following the recommendations from GAISE we also need to integrate more visual technology.

An exemplary use of technology in statistics teaching is illustrated in the paper by Harraway, John (2012) just published in the journal Technology Innovations in Statistics Education. The paper discusses "Learning Statistics, Using Motivational Videos, Real Data and Free Software". This seems to be closest to what we are interested in doing. It provided a great discussion on the use of the free software created by University of Otago Department of Mathematics and Statistics. It also provided 19 videos by their faculty applying the software in their teaching and research. The site http://www.maths.otago.ac.nz/videos/statistics/ contains valuable aids for improving teaching and motivating the learning of statistics with videos or case studies to demonstrate the practice of teaching statistics. However, it focuses on teaching students how to use technology effectively to manage data, explore, perform inference, check conditions that underlie inference procedures, etc. The focus is not on data visualization with teaching Visualization in Statistics.

Many publications in Statistics Education discuss issues related to using technology to explore data with a heavy emphasis on inference and modeling. The main goals are to encourage the teaching of statistics literacy, quantitative skills across disciplines and providing resources for undergraduates. In sum, there is a significant lack of studies and emphasis on teaching the statistical visualization for introductory courses in the body of literature. This study could set a precedent for other studies in exploring this avenue in statistics education research.

3 Research Methodology

As stated in the introduction, the purpose of our research is to address the evolving needs of students and instructors of statistics on how to integrate visualizing technology to improve the teaching and learning of statistics. We wish to evaluate the effectiveness of introducing Gapminder into an introductory statistics course and examine how having used the software affect students' attitude and perception about the course. In essence, the objective of the study is to investigate how Gapminder can help instructors increase student engagement and interest in the subject. In this study we address the following three questions using mixed methods approach:

1. *What are the benefits of using Gapminder in an introductory statistics class?*

2. *In what way does Gapminder help stimulate student interest and engage them in learning statistics?*

3. *What is the relationship between the amount of time students reported spending to complete the project and their interest level in learning and using statistics?*

In this chapter we describe the study's research methodology and includes discussion around the following areas: rationale for using mixed methods, research design, context and participants (sample), methodology, data collection, data analysis, issues on trustworthiness, limitation, and research trajectory.

3.1 Rationale for Using Mixed Methods

This study is best conducted via a mixed methods research because the richness of the qualitative and quantitative data collected from various sources, such as multiple surveys, and class records, discussion forum, etc, will enable us to triangulate our findings using mixed methods approach. Each source of data can complement each other to enhance our understanding of the studied issues. When stimulating student interest and engagement in statistics is what we focus, mixed methods allows us to look through the multiple perspectives to enhance our interpretation of the findings. Our research objectives are first to integrate both qualitative and quantitative data types to improve our findings. Second, we intend to triangulate research results to find convergence and corroboration of the findings at the same time explore divergent or disparate findings (if any) in order to gain the breadth and depth on our issues. Third, we wish to make use of quantitative information for conducting statistical analyses and standardized tests of reliability and validity, while employing qualitative data to add a narrative understanding to the findings from quantitative analysis. Finally, we wish to extend our inquiry by using results from one method to help inform the other method. Using mixed methods allows us analyze and interprete the mixed data in a single study.

3.2 Overview of Research Design

This study uses a mixed methods of quantitative to qualitative sequential explanatory approach as illustrated in Figure 1. The primary goals of our analysis are to generalize the quantitative findings, validate, compare, and contrast findings from qualitative analysis. The study seeks to investigate the effectiveness of introducing the visualization software in teaching introductory statistics courses. Within the framework of quantitative analysis we utilize different statistical methods such as descriptive statistics, two-sample t-test for comparing group means, correlation analysis to investigate relationship, and item response theory to analyze rating scores. The focus is on always on visualizing raw data as well as creating graphs to aid the interpretation of the numerical outputs. For the qualitative anlaysis, we rely more on thematic questions to extract information on respondents' views and opinions on the impact of Gapminder to their learning experience.

3.3 Context and Participants

The study was conducted in a hybrid introductory graduate statistics course with participants as students enrolled in statistics 401D-XW course. This group typically consists of graduate students and a few motivated seniors who wish to earn upper division credits. There were 74 students with roughly 60% females. The course was initially designed for graduate students in the social science areas, but attracts students from other disciplines because they can select to register for a

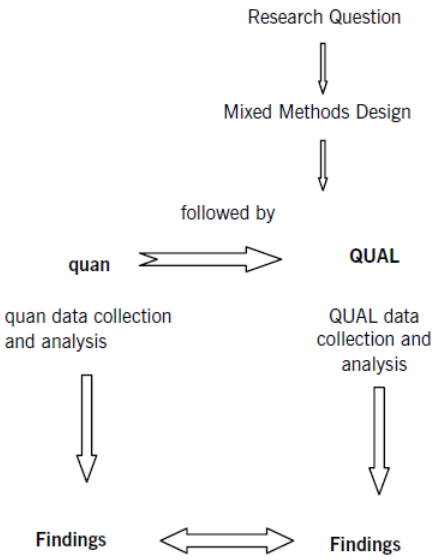


Figure 1: Mixed methods sequential explanatory design.

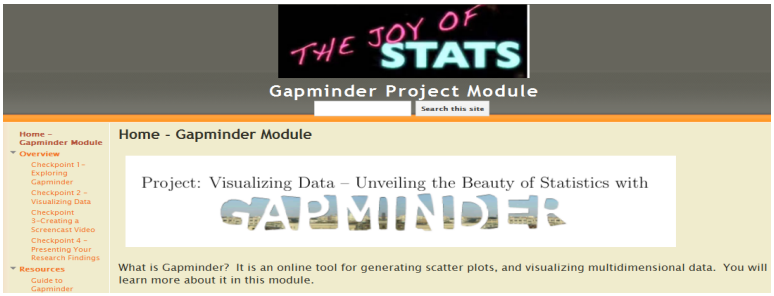
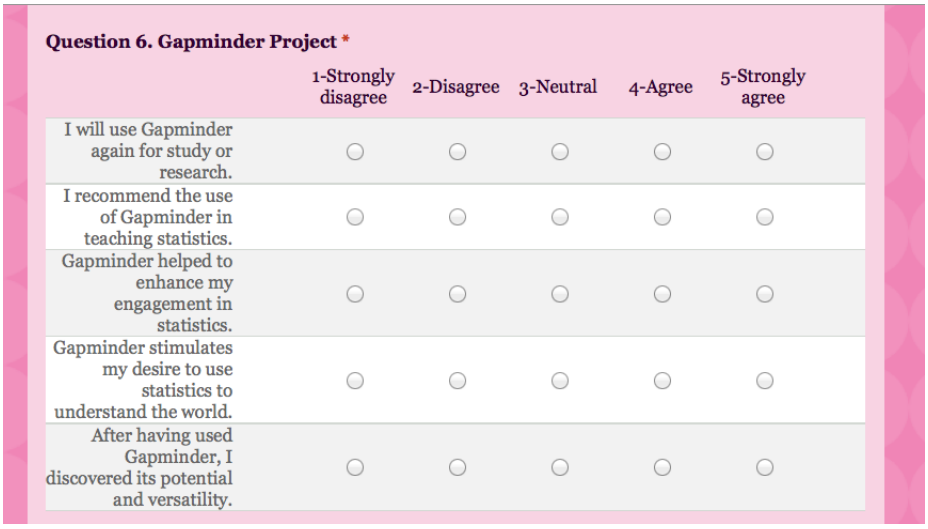


Figure 2: Frontpage Image of Gapminder Project Website.

face to face or an online section. As such, the participants come from various academic disciplines and geographic locations. All course documents were uploaded via a main portal, the Blackboard learning management system.

Students were first introduced to Gapminder via a class project and asked to conduct their own research to learn more about the software. They needed to create an animated graph and record a video explaining the story of their graph. Students submitted their weekly progress via a class wiki. A grading rubric provides requirements for their weekly submission. Student weekly progress and submission were used as data for this study which included videos, papers, discussion forum, and a survey, opinions about their experience before and after the project. Moreover, we obtained demographic data and grades from class records. Information about the project can be assessed from the website, Gapminder Project Website. Figure 3 displays the frontpage image of the Gapminder website.



Question 6. Gapminder Project *

	1-Strongly disagree	2-Disagree	3-Neutral	4-Agree	5-Strongly agree
I will use Gapminder again for study or research.	○	○	○	○	○
I recommend the use of Gapminder in teaching statistics.	○	○	○	○	○
Gapminder helped to enhance my engagement in statistics.	○	○	○	○	○
Gapminder stimulates my desire to use statistics to understand the world.	○	○	○	○	○
After having used Gapminder, I discovered its potential and versatility.	○	○	○	○	○

Figure 3: Question 6 in End-of-Semester Survey

3.4 Data Collection Methods

Data were collected using various instruments: class demographics, midterm survey, weekly submissions via class wiki, discussion forum, videos, project scores, and end of project survey. . We also used student work sample as well as presentations as artifacts for qualitative data. Quantitative data come from various sources such as student reports on the number of hours they spent on project, number of email messages sent during collaboration, and their project scores. The data used in this analysis came from two three main surveys, 1) Gapminder Project survey which contains open-ended, Likert-scale and numerical questions, 2) midterm survey, and 3) End-of-Semester surveys. A sample survey question from the End-of-Semester survey is shown in Figure 3.

Figure 4 provides a quick glance at what our students investigated for their project:

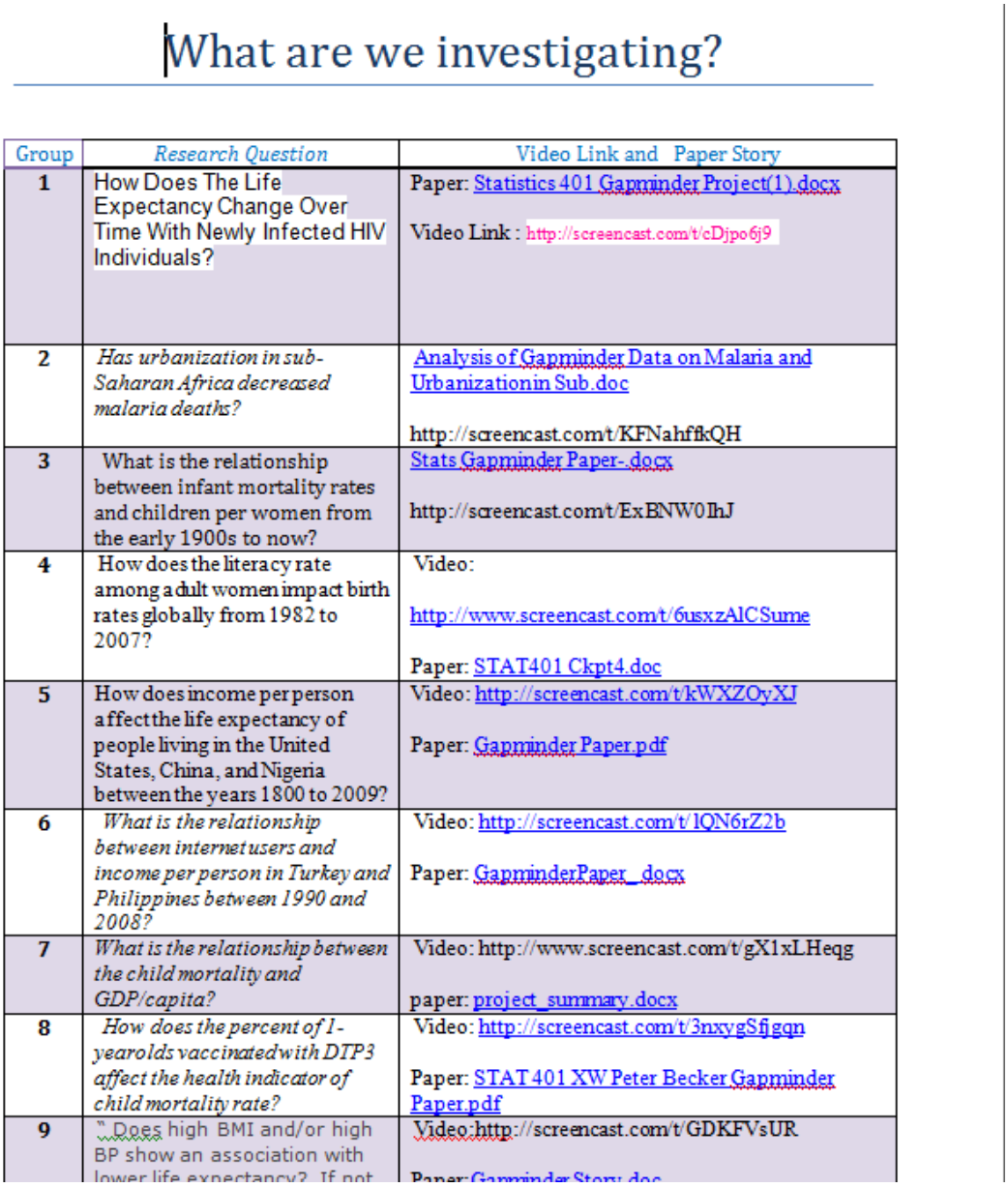
In hindsight, we consider introducing the software at the beginning rather than in the middle course. This would facilitate giving student more time to explore the software, research topics of interests, and examine other people's work.

4 Data Analysis, Findings and Discussion

Following the sequential method, we proceed with analyzing the quantitative data followed by qualitative data.

Quantitative Analysis

Descriptive Statistics: First we looked at some descriptive statistics of the raw data based on the numerical responses to some questions. When asked "**Do you promote the use of Gapminder as a tool for viewing and exploring data in an introductory statistics course?"** roughly 84% of students said yes and 16% answered no. On the question "**On the scale of 1-5, 5 for being excellent and 1 for being Poor, rate the impact of Gapminder project on your understanding and enjoyment of statistics.",** about 70% of students rated the project



What are we investigating?

Group	*Research Question*	Video Link and Paper Story
1	How Does The Life Expectancy Change Over Time With Newly Infected HIV Individuals?	Paper: Statistics 401 Gapminder Project(1).docx Video Link : http://screencast.com/t/cDjpo6j9
2	*Has urbanization in sub-Saharan Africa decreased malaria deaths?*	Analysis of Gapminder Data on Malaria and Urbanization in Sub.doc http://screencast.com/t/KFNahffkQH
3	What is the relationship between infant mortality rates and children per women from the early 1900s to now?	Stats Gapminder Paper-.docx http://screencast.com/t/ExBNW0IhJ
4	How does the literacy rate among adult women impact birth rates globally from 1982 to 2007?	Video: http://www.screencast.com/t/6usxzAlCSume Paper: STAT401 Ckpt4.doc
5	How does income per person affect the life expectancy of people living in the United States, China, and Nigeria between the years 1800 to 2009?	Video: http://screencast.com/t/kWXZOyXJ Paper: Gapminder Paper.pdf
6	*What is the relationship between internet users and income per person in Turkey and Philippines between 1990 and 2008?*	Video: http://screencast.com/t/lQN6rZ2b Paper: GapminderPaper_.docx
7	*What is the relationship between the child mortality and GDP/capita?*	Video: http://www.screencast.com/t/gX1xLHeqg paper: project_summary.docx
8	*How does the percent of 1-year olds vaccinated with DTP3 affect the health indicator of child mortality rate?*	Video: http://screencast.com/t/3nxygSfjgqn Paper: STAT 401 XW Peter Becker Gapminder Paper.pdf
9	"Does high BMI and/or high BP show an association with lower life expectancy? If not	Video:http://screencast.com/t/GDKFVsUR Paper:Gapminder Story.doc

Figure 4: Image of the Wiki where students posted their best videos and papers. You can see the entire list from this link http://screencast.com/t/7mmVveSutyZK.

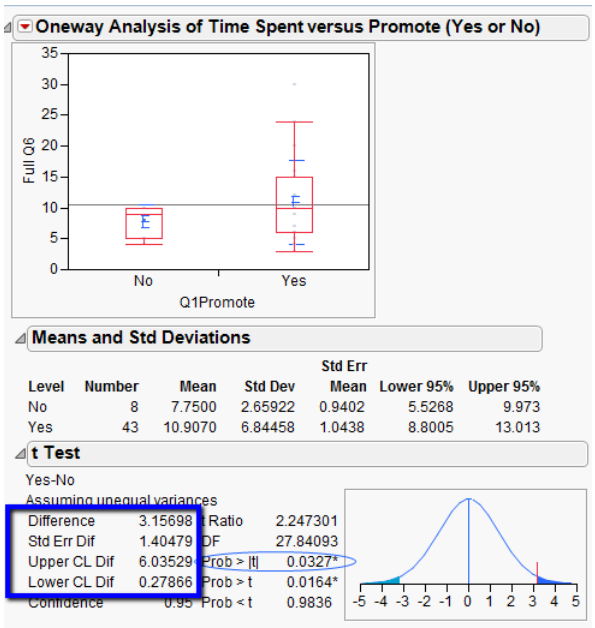


Figure 5: Two sample t-tests for time spent working on the project for the promoters and non-promoters of Gapminder.

as good to excellent. This indicate a high percentage of students who support the use of Gapminder and enjoy their learning experience from doing the project.

Inferential Statistics: When combining data from questions on "number of hours spent on the project" and "promote the use of GM" we observed substantial evidence of a positive relationship between the amount of time students worked on the project and their attitude about Gapminder. The t-test comparing the time spent between the Gapminder supporters and non-supporters results in a *p-value* of 0.0327 (t-value = 3.157 with a 95% confidence interval from 0.27 to 6.035). The results of the analysis are summarized in Figure 5.

To measure attitude of the individual repondents on Gapminder we use Item Response Theory, a statistical analysis method for analyzing Likert Scale and constructing unobserved latent variable attitude. Respondents' attitude was not measured directly but can be estimated based on their numerical rating of the questions related to Gapminder. Analysis based on responses to the item displayed in Figure 3 reveals that in general people have a positive attitude about Gapminder. Less than 50% of people believe they will use it again in their study or research but the majority (72%) recommend it to be used in teaching statistics. 57% percent agreed that Gapminder stiumlates their desire to use statistics to understand the world and helped enhance their engagement in statistics. An overwhelming proportion (75%) rated agree to strongly agree for question on discovering the potential and versatitlity of GM after having used it. The attitude scores were extracted based on the proportion or probability of peopel rating the questions at a specific level. Figure 4 exhibits the probability curves for all five items in Figure 3.

Figure 7displays the amount of information on attitude each item in the question contribute to construct the attitude of individual respondents. Roughly each item contributes an equal amount of information (20%) on attitude of the repsondents with the second item, Recommend, (in red) share the lowest portion (18.5%). People with attitude scores between -2 to 2 contribute the most information (approximately 93%). The other 7% of information come from people at the two extremes, very negative or very supportive of Gapminder.

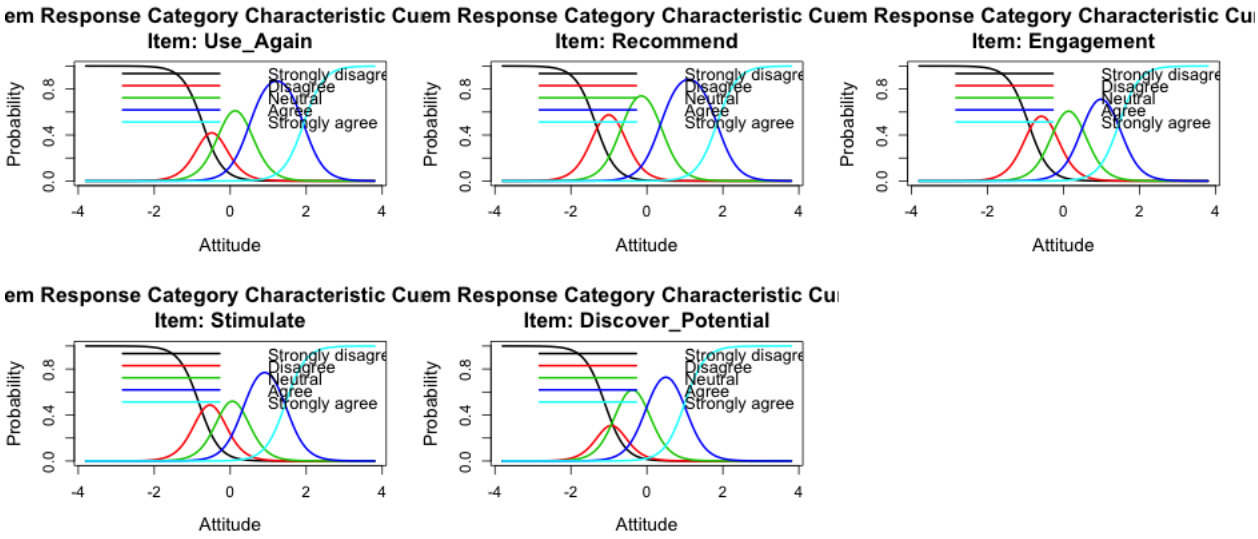


Figure 6: Display of Item Characteristics Curves, results from Item Response Theory analysis. relationship between respondents' attitude score and their likelihood of endorsing/rating an item at a specific score. People with positive attitude (*attitude scores* ≥ 0) tend to rate all these questions with high scores and the reserve for those with negative attitude scores.

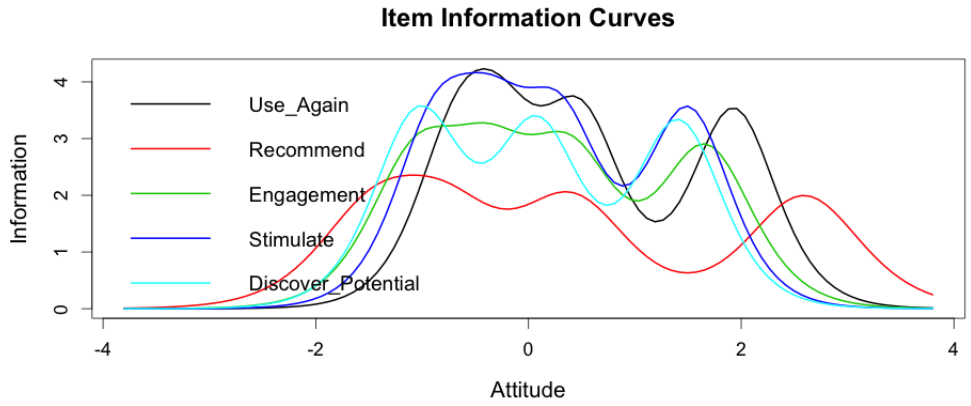


Figure 7: Item Information Curves. All five items contribute

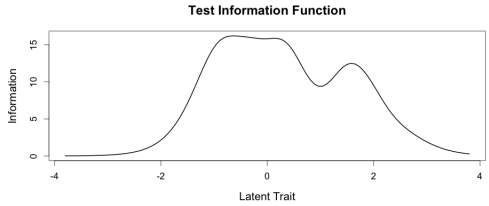


Figure 8: Total Item Information

Figure 9: Density plot of Attitude Scores extracted from Item Response Analysis

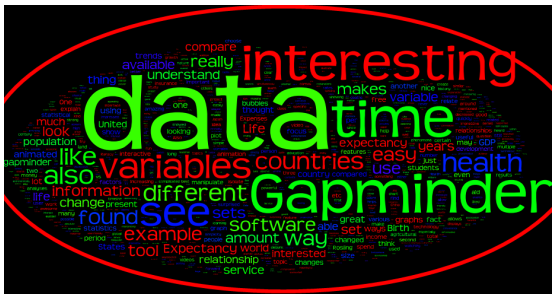


Figure 10: Wordle created from students' comments about Gapminder during the first week. The higher the frequency of a word, the larger the font size. Data, Gapminder, intersting, time, see, understand, health easy, are a few of those words that can be picked out easily from the cloud.

These attitude scores can be extracted to use in subsequent regression analysis to understand factors that influence respondents' attitude toward the software use. The plot of the attitude scores in Figure 9 shows that the attitude scores have a fairly symmetric bell-curved distribution, with most values clustered around the range -2 to 2. This suggests that people having a fairly neutral attitude about Gapminder in relation to their statistics learning experience.

Qualitative Analysis

The challenge throughout data collection and analysis for this project as for any research that involves qualitative data was to make sense of large amounts of data. Data analysis are being conducted to incorporate both quantitative and qualitative methods. We conducted initial coding using results from each checkpoint to identify students common areas of interest. The word cloud in Figure 10 shows a graphic representation of students' comments after their first exposure to Gapminder.

Initially, we made use of the initial summary from Google docs to identify our coding themes as seen in Figure 11. Students' videos will be analyzed for learning engagement based on their in-depth exploration of their group topics.

In addition, we assess students technological skills based on their ability to embed different technology tools into producing videos. The findings from qualitative and quantitative analysis will be combined for comparison, validation, in answering the research questions. Detailed analysis and findings, interpretations and implications will be provided in chapters 4 and 5. To gain a better

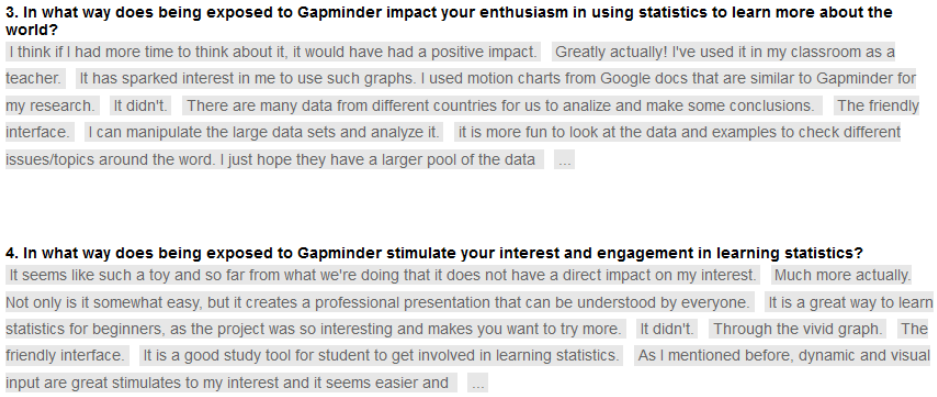


Figure 11: Summary of Questions 3 and 4 in Gapminder Survey from Google docs.

understand on responses (Yes or No) to the first question related to promoting Gapminder, we asked the second question: **What did you like best about Gapminder? What did you like least about Gapminder.** The results indicate that there are six primary reasons people like Gapminder: 1) the visual aspect of it ("visually viewing the data make learning about them more interesting.", 2) animation feature, 3) interactive component ("users can interact with a moving graph"), 4) the free and availability of the software, 5) easy and intutive to learn, and 6) interpretable approach. On the other hand, most people complained of the data features which have lots of missing data since data are spanned 200 years and many country did not have data. Another common dislike of Gapminder is actually not on the software but the use of it as a class project. Many people perceived that the project added more work to the course workload which most students considered heavy. These negative comments help us plan better for future courses.

To obtain data for the second research question:

1. *In what way does Gapminder help stimulate student interest and engage them in learning statistics?*

we asked **"In what way does having used Gapminder stimulate your interest and engagement in learning statistics?"** . About 80% of students indicated that **Fun** is the main factor as stated in the following quotes: "Using Gapminder made me feel like Statistics is not a "dry subject". "It makes working with data enjoyable." "For me, use of Gapminder led to a new and rejuvenated interst in statistics." "It is a great way to learn statistics for beginners, as the project was so interesting and fun that makes me want to try more."

We are learning to integrate NVivo to analyze text-based data such as students' papers, surveys, discussion forums as well as video contents. The goal is to gain insight on their interest, enthusiasm and engagement. In returning to the three research questions that guide our study, we can summarize the main points as:

1. **What are the benefits of using Gapminder in an introductory statistics class?**

   - Students were more engaged in learning as they work with real data. Thus most students promote the use of GM.
   - It encourages student to explore and conduct meaningful analysis and be creative in utilizing different technologies such as animation, interactive, and visual.
   - GM enhances student learning experience, facilitate interpretating of analysis results.

2. **In what way does Gapminder help stimulate student interest and engage them in learning statistics?**

   GM helps create the 3M's environment:

   - **M**eaningful: it makes learning statistics more meaningful and practical.
   - **M**emorable: it creates lasting impact, making learning more memorable.
   - **M**otivational: it motivates students to dig deeper, explore, and investigate.

3. **Does student interest increase as they spent more time on the project?**

   Yes, the more time students spent on the project, the more they support and promote GM, and the better attitude they have about statistics.

In summary, the results reveal a positive impact of Gapminder on student learning experience and engagement in statistics. Using mixed methods allows us to triangulate results. By examining quantitative results and themes from qualitative data we can have a better understanding of why students did and did not support the use of Gapminder; What excited them about the software and what caused them to dislike it. We can also extract the factors that help stimulate their interest and engagement in the project and in the course. The results indicate that the more time students spent on the project, the more supportive they are which stimulate more engagement and develop a positive attitude about learning statistics. This study can be expanded to different levels of beginning statistics to increase sample size and thus validate statistical conclusion. And it may lead to further investigation and implementation across curriculum to the K-12 sector.

5 Concluding Remarks

In summary, this study highlights the significance of implementing more visualizng technology to improve the teaching of statistics and enhance student learning engagement. Mixed methods was employed to mix two dierent methodologies within a single study to investigate the effectiveness of introducing visualization software Gapminder into beginning statistics courses. The intent was that this study would make a contribution to the understanding of incorporating and teaching statistics with visualization to boost student learning engagement. The results validate our belief that Gapminder allows students to make use of the global data to analyze trend and issues. As a result, it assists instructor to achieve high level goals on the Bloom taxonomy through requiring students to analyze data and evaluate outcomes. It is our hope that students would be impacted forever by having used Gapminder as they expand their curiosity in statistics and gain some useful skills in using technology.

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