State Cost Competitiveness Dashboard

An Interactive Qualifying Project Report Submitted to the Faculty of The WORCESTER POLYTECHNIC INSTITUTE In Partial Fulfillment of The Requirements for The Degree of Bachelor of Science By:

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Abstract

The goal of this project is to build and analyze the effects of an interactive web-based dashboard for the Massachusetts High Tech Council, a pro-technology advocacy and lobbyist organization. We conducted a survey of Massachusetts High Technology Council (MHTC) members about the perceived effectiveness of the dashboard as well as a usability study of the dashboard prototype to test the ease of use. This allowed us to better understand the impact of technology in policy making.

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1 Introduction

The goal of this project is to build a front-end interface for the Massachusetts Technology, Talent and Economy Reporting System (MATTERS) website which will serve as a dynamic and searchable dashboard. This dynamic dashboard will provide quick, intuitive, and easy-to-use analytics for data relevant to Massachusetts' competitiveness and talent development. The ultimate goal is to help propose policy changes in order to improve conditions for developing new high tech businesses in Massachusetts. The IQP (Interactive qualifying project) group will work in collaboration with other sub-teams consisting of WPI graduate students in developing the MATTERS dynamic dashboard. On the technical aspect the IQP group will be responsible specifically for building the dashboard interface. However the emphasis of this IQP is not building the dynamic dashboard but understanding the social aspects of it.

The project is sponsored by the Massachusetts High Tech Council (MHTC). For this phase of the project, the factors considered that have an impact on the High Tech and Life Sciences economy are:

- State and Local Tax Burden "per capita" and "% of personal income"
- Economy: Total Employment
- Economy: Tech Employment
- Economy Unemployment Rate
- Talent Development Metrics
- Unemployment Insurance Payroll Tax

These factors and other similar categories will be called metrics throughout the project. Massachusetts will be compared using these metrics with 15 competitor states (referred to as peer states) with the goal to enhance job creation and have a more innovative economy. The 15 peer are:

California	Minnesota	Texas
Colorado	New Hampshire	Utah
Connecticut	New Jersey	Virginia
Georgia	New York	Washington
Maryland	North Carolina	Pennsylvania

2 Literature Review

The dashboards discussed in the next few paragraphs are commercial and are customizable. Customizable mainly relates to the fact that user can choose between different data visualizations (charts, graphs, static images, or other media contents) and position them at different parts of the page in drag-and-drop fashion.

2.1 State of the art dashboards

The Oxford dictionary[1] defines a dashboard a "graphical summary of various pieces of important information, typically used to give an overview of a business". It is often a single page, easy to read graphical representation of data including bar, pie, column, or bubble charts, bullet graphs, line graphs, geographic charts, etc. One particularly important feature is the real-time user interface that lets the user visualize the same data using different techniques. Giving insight to changing data trends often involves displaying real-time, changing data in form of gauges, or only shows data changes in the past using line charts. Some of the commonly used visualization types are shown in Figure 1.

[1] http://www.oxforddictionaries.com/us/definition/american_english/dashboard

Figure 1 - Visualization types

2.2 Microstrategy Dynamic Enterprise Dashboards

Microstrategy develops and sells mobile software and provides cloud services to help organizations and businesses analyze and visualize data interactively. Notable clients include Facebook and Starbucks. They aim to provide easy-to-use dashboards offering various types of data visualization tools such as tables, graphs, graph reports, trend

indicators, gauges, heat maps, etc. Navigation and analysis are made possible through drop-down boxes and radio buttons (selector controls), and there is no need to learn any commands or menus. Their dashboards are HTTP-accessible. Documents are displayed in DHTML, Flash or both.

Figure 2 - Microstrategy dashboard Example 1

On the dashboard example on Figure 2 the user selects between different categories (Region and branch in this case) and different time periods on the top of the page. For each selection, the dashboard shows the same visualizations with different data. Micro charts that are shown in the middle of the page are basically small line charts without labeled axis. They are automatically updated to show weekly, monthly and/or yearly trends. Two comparative area charts and column-line charts show data changes through time more precisely with the ability to observe data at different times by changing time axis. Bar charts are used to compare the same data metrics across different categories (in this case there is a comparison of average transactions between different regional branches).

Figure 3 - Microstrategy dashboard example 2

Figure 3 shows an example of a geo-chart where metrics are plotted as circles according to their location on the map. The type of metric is indicated by the color of the circle and the value of the metric is shown by the radius of the circle. A similar concept is used with the bubble chart (bottom right on Figure 3). The only difference is that the metrics are mapped to 2 dimensional charts (in this case price on y-axis and number of items on x-axis) instead of a location on the geo-chart. On the right there is a selection panel where the user can apply different filters in order to visualize different data.

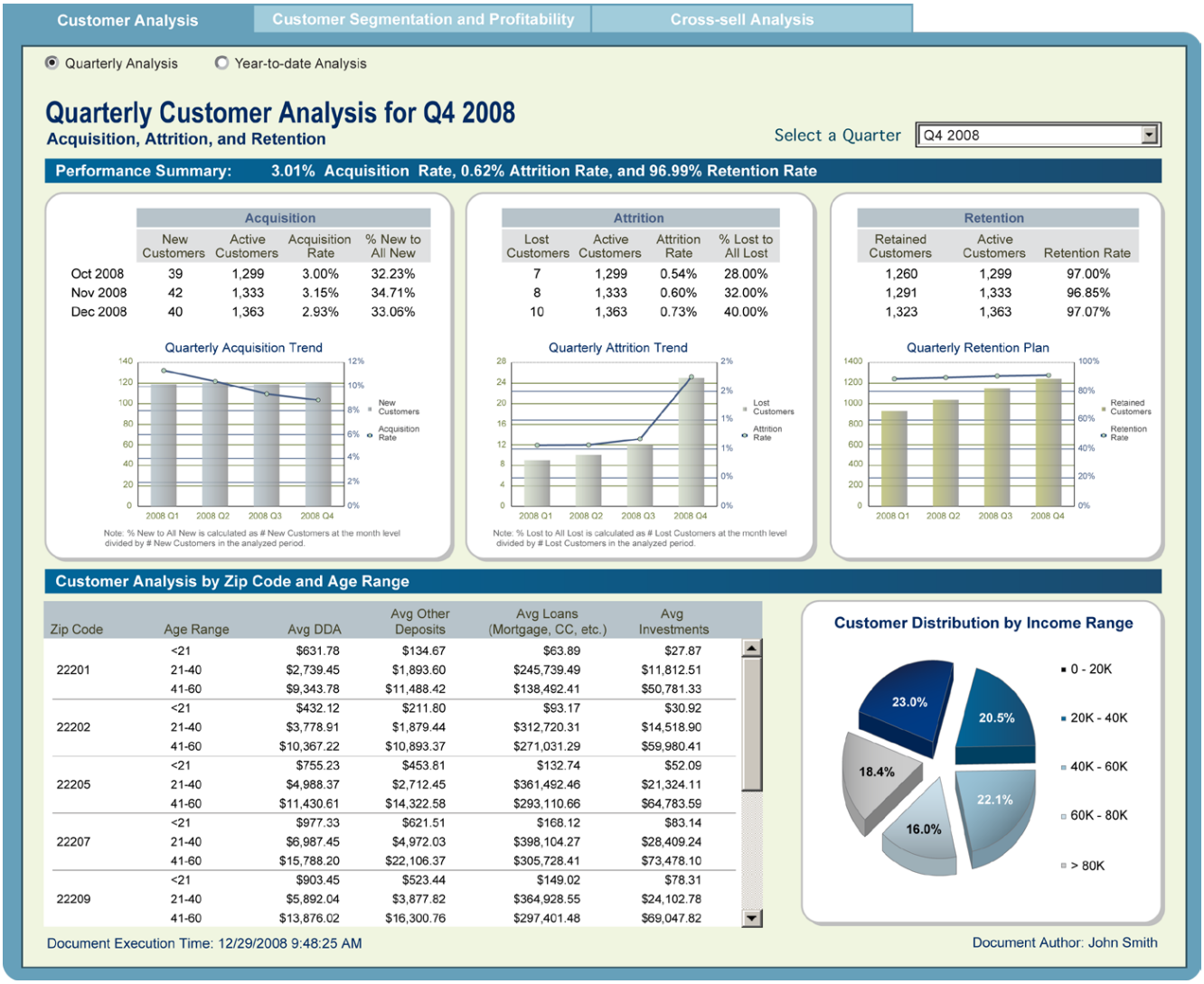


Figure 4 - Microstrategy dashboard example 3

2.3 Qlik Dashboards

Qlik Technologies is a company that sells business intelligence software for visualizing, searching and analyzing data through interactive dashboards with engaging graphics. Prices range from $0 for personal edition to several thousand for commercial use. Figure 3 shows one of their "demo apps". On the left there is a selection panel with different filters. Filters include months, years and year quarters.

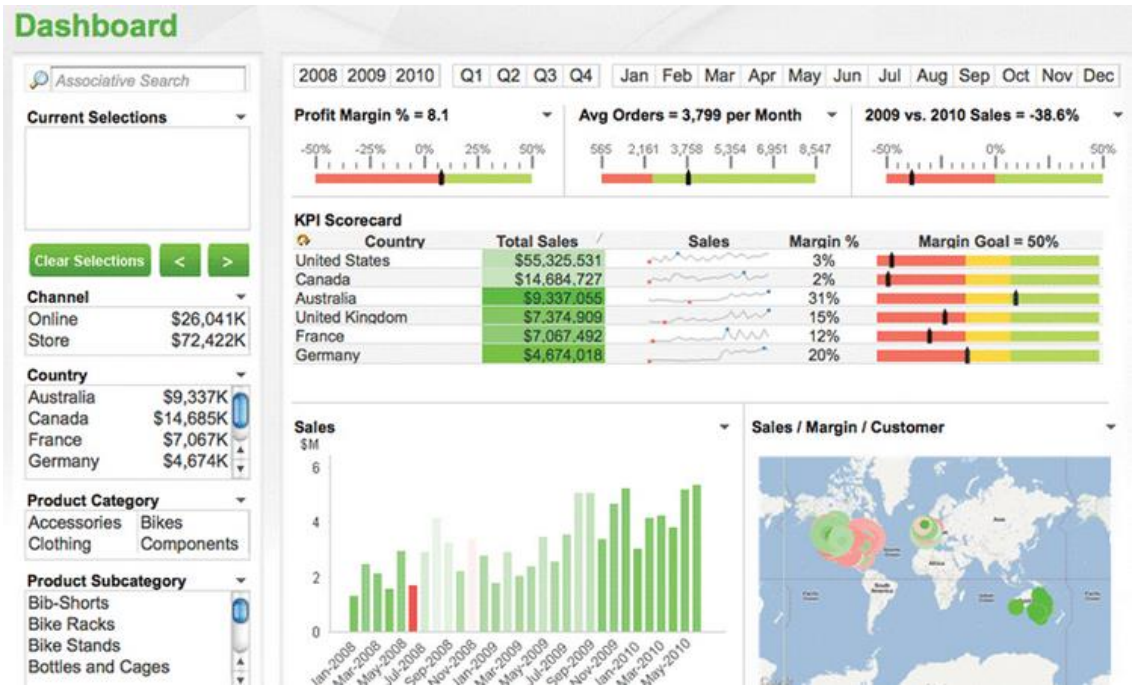


Figure 5 - Qlik dashboard example 1

2.4 ClicData Dashboards

ClicData provides free personal dashboards. Professional or enterprise plans cost in the range of $20 to $50 per month. Data can be imported through Excel, CSV, Dropbox, Google drive, SkyDrive, FTP, and MySQL. Reports can be exported in Excel, PDF or Word. Also plans differ on data storage and on how frequently the data can be updated ranging from weekly to one a minute.

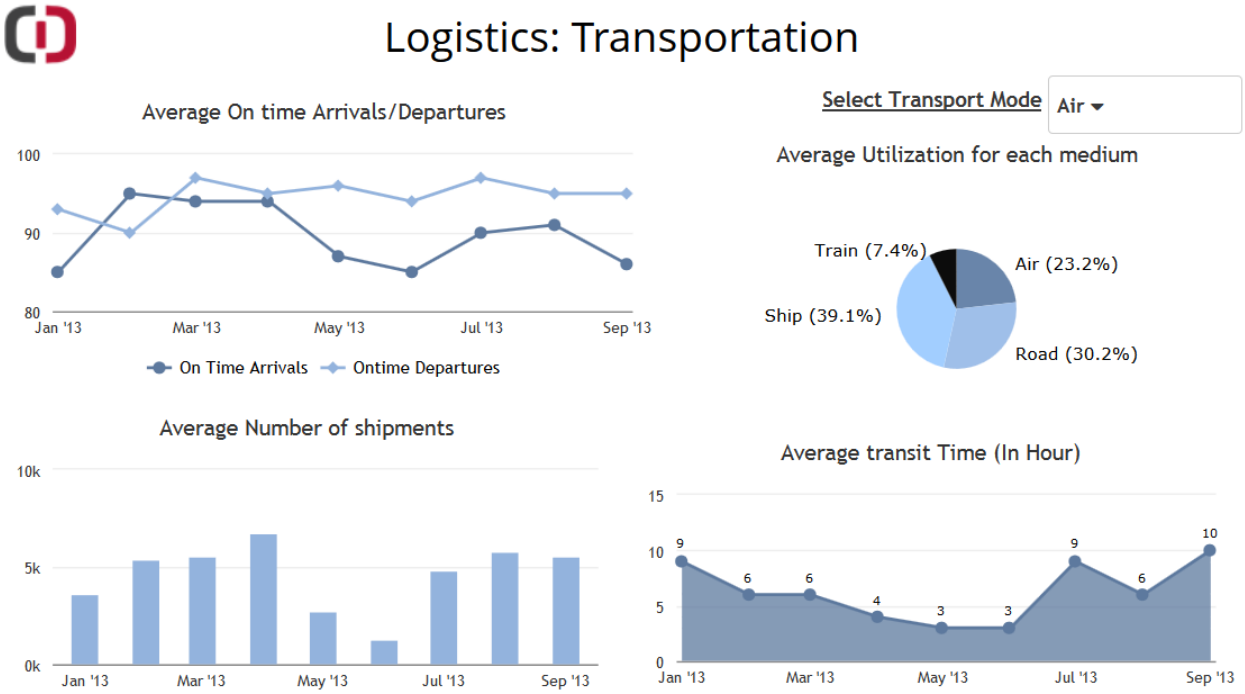


Figure 6 - ClicData dashboard example 1

2.5 Conclusion after literature review

Through the market research we learned that there are several competitive web based dashboard builders with very complex features.

Dashboard builders allow average user without any programing experience to design a dashboard using graphical user interface. This project will not use any of these commercial services due to monetary constraints. Our project deals with building web based dashboard from scratch using at least the following technologies: HTML, CSS, and JavaScript. On top of that our project is also responsible for the complete web design itself. More so, great care must be taken in documenting all the work to enable future developers to continue this work (e.g. code must have comments). The First generation of our dynamic dashboard was aimed to have the following visualization types:

- Line graph - presenting one of more metrics versus time.
- Bar/Column charts - presenting certain metric against different states.
- Geographical charts - presenting one or more metrics across different states using color code, circles with different radius and the combination of those.
- Tables - presenting any one metric against the other.

The Second and final generation of our dynamic dashboard ended up having the following:

- Line graph - presenting one of more metrics versus time.
- Geographical charts – used for selecting the states for comparison
- Tables – presenting list of metrics under specific bin

3 Project Description

In order to understand all the data being presented on the dashboard as well as the terminology, one should start from the high level view of the performance of states. An example of high level overview of Massachusetts is on Figure 7, which is expressed through eight rankings or metrics. I**ndexes** (listed in the Introduction) can be broken down into **categories** and **categories** are further broken down into **metrics**. Metric is a specific measure of state's performance. This hierarchy comes from the sources listed in Figure 7. However, the word "metric" tends to be used in ambiguous ways interchangeably for any group of data depending on the data source. This report will try to use the word "metric" only for single specific group of data that cannot be broken down in sub-metrics. The IQP group works in collaboration with several other groups like:

- Software Framework
- Data Modeling and Warehouse
- Data Acquisition and Pipeline
- Software Development Methodology

It has been decided that the following 6 indexes are most influential to the business climate in Massachusetts and they will be shown on the dynamic dashboard whose interface is to be designed by the IQP group. High level indexes will be shown in form of a table on the homepage of the dynamic dashboard. The main 6 indexes and other indexes that are to be added in future will be distributed through corresponding bins namely: Talent, National, Cost, Economy. The 6 rankings are:

- State and Local Tax Burden "per capita" and "percentage of personal income"
- Economy: Total Employment
- Economy: Tech Employment
- Economy Unemployment Rate
- Talent Development Metrics
- Unemployment Insurance Payroll Tax (In dollars per employee)

Massachusetts National Rankings

Index/Survey	Source	Year/# Ranking				
State Science and Technology Index	Milken Institute	Yr:	'02	'04	'08	'10	'12
		#:	1	1	1	1	1
Top States for Business	CNBC	Yr:	'09	'10	'11	'12	'13
		#:	8	5	6	28	16
State Tax Business Climate	Tax Foundation	Yr:	'10	'11	'12	'13	'14
		#:	N/A	28	23	22	25
State Tax Cost on Business (single year report)	KPMG/Tax Foundation	Yr:	'N/A	'N/A	'N/A	'N/A	'12
		#:	N/A	N/A	N/A	N/A	44
Cost of Doing Business	CNBC	Yr:	'09	'10	'11	'12	'13
		#:	40	39	41	49	47
Unemployment Insurance Payroll Cost	Tax Foundation	Yr:	'10	'11	'12	'13	'14
		#:	N/A	N/A	49	49	49
% Workforce with BS Degree or Higher (3yr Average)	Mass Technology Collaboration	Yr:	'09	'10	'11	'12	'13
		#/%:	1/47	1/45	1/45	1/45	1/45
% of Workforce in High Tech Business	National Science Foundation	Yr:	N/A	N/A	'03	'07	'10
		#/%:	N/A	N/A	3/15.5	2/16.1	6/15.1

N/A = Data not available

Figure 7 - Massachusetts national rankings

3.1 State Science and Technology Index

In order to show complexity and huge number of different measures of state's performance only single index will be expanded to lowest data groups which are metrics. For instance, The State Science and Technology Index[2] uses the following categories:

- Human Capital Investment
- Risk Capital and Entrepreneurial Infrastructure
- Research and Development Inputs
- Technology Concentration and Dynamism
- Technology and Science Workforce

Human capital is a combination of competences and knowledge of people that makes them able to produce economic value through their work and creating the future social and economic welfare. Government controls human capital or people resources mainly by investing in education or in job skills training. It has become increasingly evident that human resources rather than physical resources are more influential on economic development and productivity growth. There are 21 metrics that reflect Human Capital Investment. The long list of metrics is available in Appendix A.

[2] http://statetechandscience.org

Proper entrepreneurial infrastructure set by new government policies will boost the economic growth and development. Risk capital means funds assigned for an activity that may either earn great return or end up in losses over a period of time. According to the Chien-Chi Tseng's paper[3] "entrepreneurial infrastructure represents the facilities and services present within a given geographic area that encourages the birth of new ventures and the growth and development of small businesses". Examples for these facilities and services are accelerators and incubators that help startup companies with funds, mentorship, facilities and tools. Risk Capital and Entrepreneurial Infrastructure category is characterized by 12 metrics represented in Appendix B.

Research and development means business activity that either develops new products by engineers or creates new knowledge by industrial scientists. R&D is usually part of any modern especially technical firm. Risk capital is related to R&D due to uncertainty of future profit and benefits that it might bring. However it is shown that companies that invest in R&D exhibit positive effect on productivity and innovation as well as number of patent citations. There are 18 metrics behind Research and Development Inputs Composite Index (Appendix C).

In the 21 century economy, state competitiveness will become increasingly dependent on technology-based companies. STEM fields (Science, technology, engineering and science) have a high impact on science workforce development which is essential in the technological and therefore economic competitiveness of a state. According to government website articles[4] there is an alarming need for STEM degrees. However, IEEE spectrum article[5] claims opposite and states that the reason for STEM degrees is mainly government's anxiety of falling behind economically and national security risk. There are 23 metrics (Appendix D) for Technology and Science Work Force Composite Index related to numbers of engineers, computer and information science experts, and life and physical scientists.

The Technology Concentration and Dynamism category is related to the number of high-tech companies and their growth rate. High-tech and high-growing companies for software, electronics and biotechnology invest more of their revenue on research and development which results in higher patent portfolio and more innovative economy. There are 12 metrics for Technology Concentration and Dynamism (Appendix E).

[3] Linking Entrepreneurial Infrastructures and New Business Development
[4] Science, Technology, Engineering and Math: Education for Global Leadership
[5] The STEM Crisis Is a Myth

4 Procedure and Methodology

The dashboard was built with mostly familiar tools and technologies in order to reduce the time spent on technical side of the project and to have more time for the social side of the project. In order to understand the impact of the technology (web dashboard in our case) on the society (government and policy changes) and how to visualize relevant metrics most effectively we will conduct a survey targeting MHTC board members and a usability study for general audience (in our case WPI undergraduate students). The justification for these target groups is provided further.

The high-level project work plan was:

C term:

- Design front end interface with mock data
- Understand the data structures
- Preparing the survey

D term:

- Connecting the front end to real data
- Conduct the survey(s) and analyze the results
- Refine the dashboard to incorporate feedback
- Explain social implications of a dashboard through project report

4.1 Survey

Feedback from users is essential in order to develop a project. In order to accomplish that, we conducted the survey to the target users and refined the dynamic dashboard correspondingly. However, since the dashboard audience will be lobbyist and/or politicians that are hard to get in touch with, it has been decided that two different surveys could be used. One survey targets MHTC members and social aspects and another one will consist of a usability study targeting the more technical side of the MATTERS dynamic dashboard. The feedback from the usability study can give us more insight about how visually appealing and convincing the dynamic dashboard is and how easy-to-use it is. Furthermore, the MHTC survey will help us understand the social impact of the dashboard on its primary users and beyond.

Questions for the MHTC survey have been refined several times through consulting with Mark Catizone and Chris Andersen from MHTC, as well as with other sub-group members.

5 Results and Discussion

The analysis of data from both, MHTC survey and usability study has been done using the Qualtrics survey tool provided as a free service to WPI students. The statistics for each question were calculated and discussed below.

5.1 MHTC Survey

The purpose of this survey was to justify and understand why certain metrics were targeted as main metrics to be displayed on the homepage of the MATTERS dashboard. The target group of this survey were MHTC board members, primarily because they are familiar with the subject we are researching. In order to increase the response rate, we only included very few questions about the dynamic dashboard user interface. Therefore it has been decided that another survey covering MATTERS interface usability will be conducted once it gains enough functionality. The reason a separate usability study is used, is that participants can be internet users in general which will reserve more important questions for MHTC board members.

The Qualtrics survey tool was very helpful in analyzing and visualizing the survey results. For instance, the percentage for each answer choice was calculated automatically. Twenty nine participants took the MHTC survey.

1. How important is the role that technology plays in collecting, aggregating and presenting data in decision making?

#	Answer		Response	%
1	Very Important		21	72%
2	Important		8	28%
4	Insignificant		0	0%
3	Not Important		0	0%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.28
Variance	0.21
Standard Deviation	0.45
Total Responses	29

This question deals with data management. Huge volume of raw data would be ineffective to store in any other way except in a database. When presenting data there is a need for data processing and translating the same amount of information into a smaller data set that policy makers can interpret. However, the database has to store raw data in order to be able to perform all different kinds of processing by request. In this case also the database management system is the solution which is confirmed by most answers, 72%. The answers to first two questions aim to justify the use of the web based dashboard. Web accessible analytics tool enables people to get insight into the data without a need for installation of additional software and regardless of geographical location.

2. How important is the internet in promoting the competitive position of Massachusetts' high-tech business compared to other states?

#	Answer		Response	%
1	Very Important		18	62%
2	Important		11	38%
3	Not Important		0	0%
4	Insignificant		0	0%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.38
Variance	0.24
Standard Deviation	0.49
Total Responses	29

With the use of World Wide Web the distribution of data is much more effective. A majority of survey participants 62% are in favor of internet usage. This justifies the use of database design tools and technologies that will facilitate this data distribution. This way the data is publicly available even in the remote locations.

3. How important is the economic performance in opening a new high-technology business?

#	Answer		Response	%
1	5 - Very Important		16	57%
2	4		12	43%
3	3		0	0%
5	2		0	0%
6	1 - Not Important		0	0%
	Total		28	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.43
Variance	0.25
Standard Deviation	0.50
Total Responses	28

In the 21st century the new economy is closely related to high-technologies. Shares of High-technology Industries are taking off rapidly shaping the entire economy. Furthermore, high-tech industries have increasing numbers of jobs and above average salaries. The answers to this question make it undoubtable that state's economy directly affects one's ability to open a high-tech business. An interesting visualization of products that US exports is shown on Figure 8. The greatest part is taken by "Machinery & Transport Equip." (Light blue area) shows that the biggest blocks are Electronic microcircuits (3%) and Cars (3%). To conclude, products related to high-tech have the most of the export percentage which also makes a great impact on the economy. This question aims to justify the importance of economy to state's competitiveness as well as the use of the "Economy" bin on the dashboard homepage.

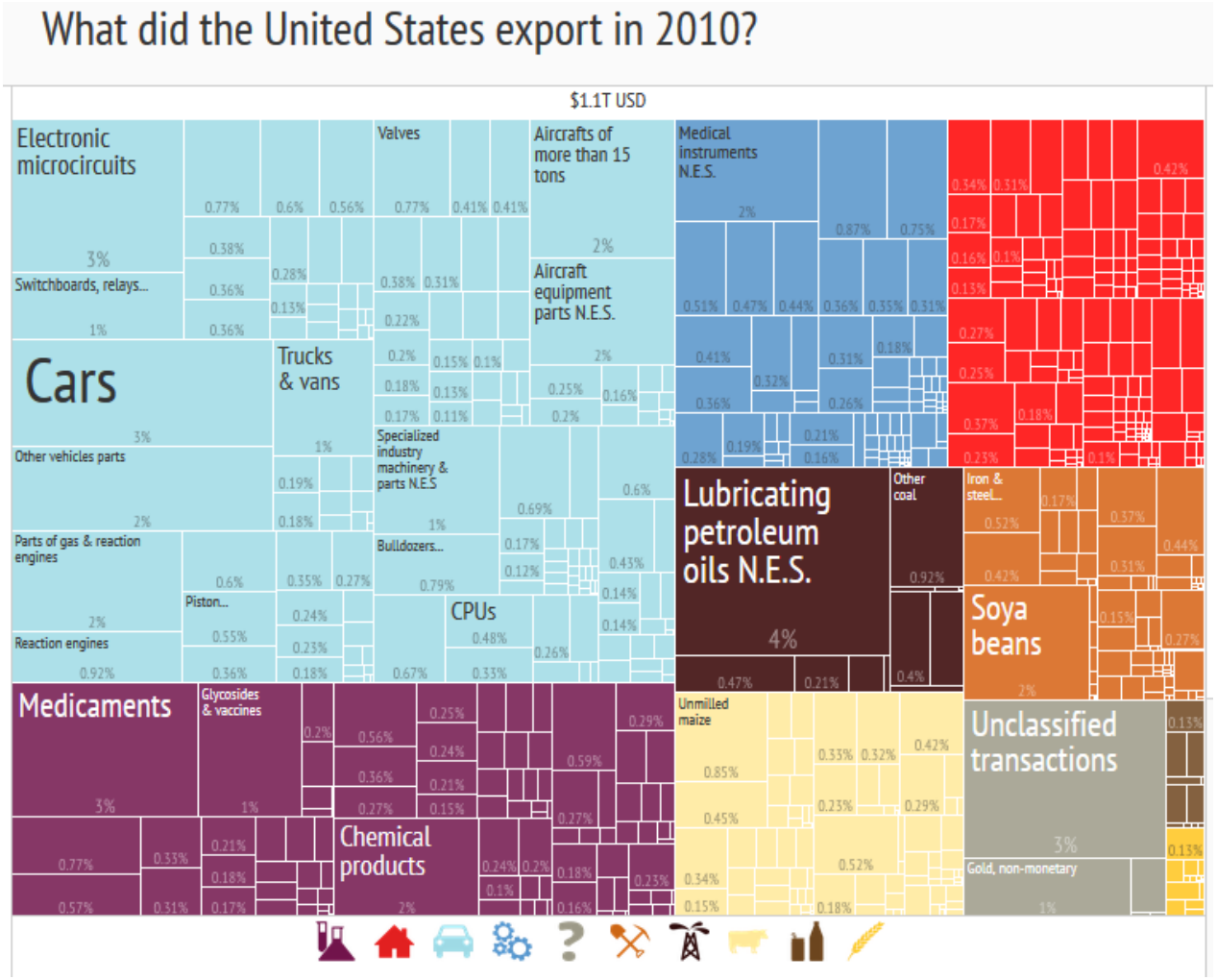


Figure 8 - Products that US exports from 2010[6]

[6] http://www.atlas.cid.harvard.edu/explore/tree_map/export/usa/all/show/2010/

4. How would you describe the effect of Science, Technology, Engineering and Math (STEM) programs in a local area on successful business operations?

#	Answer		Response	%
1	Very Beneficial		11	39%
2	Beneficial		16	57%
3	Negligible		1	4%
4	Harmful		0	0%
5	Disastrous		0	0%
	Total		28	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	1.64
Variance	0.31
Standard Deviation	0.56
Total Responses	28

High number of degrees in Science, Technology, Engineering and Math are a great foundation for advanced professions like medicine, computer science, engineering etc. that mainly constitute today's businesses.

5. How important is the reporting functionality (e.g. exporting analyzed data in PDF) to a metric dashboard system?

#	Answer		Response	%
1	Very Beneficial		4	14%
2	Beneficial		19	68%
3	Negligible		5	18%
4	Harmful		0	0%
5	Disastrous		0	0%
	Total		28	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	2.04
Variance	0.33
Standard Deviation	0.58
Total Responses	28

According to the survey results reporting functionality does not have the highest priority and therefore will be left for future improvements. The Point of reporting the processed results is to record representative data visualizations which avoids performing the processing and analysis on dashboard each time the same results are wanted. At this stage the dashboard does not have any complex data processing tools, nor a big audience which postpones the need for data-reporting functionality.

6. How beneficial is it to provide direct link to data sources for convincing ranking of metric dashboard system?

#	Answer		Response	%
1	Very Beneficial		5	17%
2	Beneficial		18	62%
3	Negligible		5	17%
4	Harmful		0	0%
5	Disastrous		1	3%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	2.10
Variance	0.67
Standard Deviation	0.82
Total Responses	29

It is surprising that a significant amount of responses (17%) show that the data sources are negligible in providing convincing ranking of metrics. In spite of that, data sources will be stated clearly on a homepage of the dashboard not only to convince the users that the data is legitimate but also to avoid copyright infringement.

7. Open response/comments area. (What will make web dashboard successful and how would you measure that?)

Text Response
Understandable, both in the displays and in the underlying data. updates effectively at defined and displayed intervals, becomes a referenced tool by policy makers in the state
Updated in a timely manner with historic comparisons. Simple with drill down functionality by clicking. Maybe filtering capabilities if drill down is not appropriate.
live/almost live updates

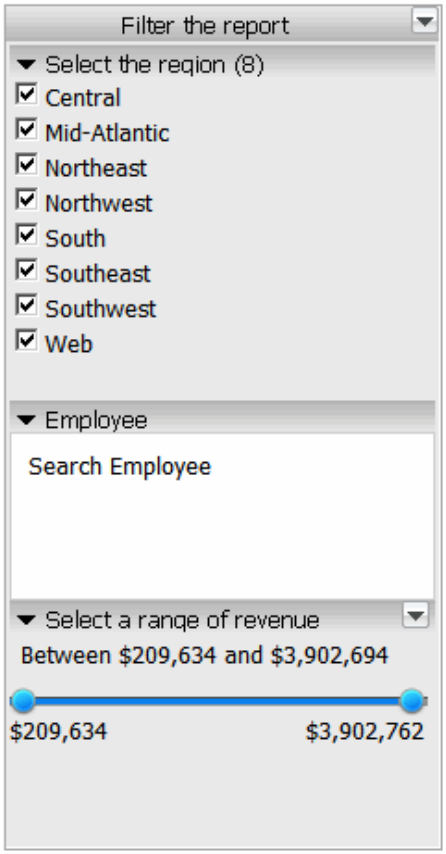
Statistic	Value
Total Responses	3

The open response yielded following dashboard enhancements:

- Data updates in timely manner (performed by data acquisition and pipeline group)
- Data filtering capabilities (data modeling and web interface team to some extent)

The IQP project is concerned with the initial phase of the dashboard which means that the first set of metrics (rankings) will be installed on the homepage where other updates are most likely to come from future groups as the project evolves.

However, data filtering capabilities are within the scope of IQP project and implementation of this will be considered. Filtering data is usually implemented with checkboxes (selects specific metrics, e.g. states), search box (search for a keyword) or slider (select the range of values). Example from Microstrategy dashboard is shown on Figure 9.



Region	Employee	Metrics	Revenue	Cost	Profit
Central	Ellerkamp	Nancy	$847,227	$720,449	$126,778
	Gale	Loren	$1,669,290	$1,416,036	$253,254
	Torrison	Mary	$1,690,350	$1,430,865	$259,485
	Zemlicka	George	$822,500	$697,693	$124,807
Mid-Atlantic	Bernstein	Lawrence	$1,060,632	$901,702	$158,930
	Brown	Vernon	$331,735	$280,504	$51,231
	Corcoran	Peter	$325,147	$275,752	$49,395
	Folks	Adrienne	$1,047,776	$888,702	$159,074
	Hollywood	Robert	$1,026,874	$871,679	$155,195
	Ingles	Walter	$229,439	$194,851	$34,588
	Smith	Thomas	$221,379	$188,010	$33,368
Northeast	De Le Torre	Sandra	$607,895	$514,795	$93,100
	Kelly	Laura	$2,350,720	$1,992,726	$357,994
	Kieferson	Jack	$584,933	$497,463	$87,470
	Sawyer	Leanne	**$2,411,912**	$2,043,693	$368,219
	Sonder	Melanie	$295,108	$251,183	$43,925
	Yager	Beth	$2,303,847	$1,953,823	$350,024
Northwest	Becker	Kyle	$508,234	$430,346	$77,887
	Gedot	Harriet	$739,741	$629,086	$110,655
	Hall	David	$513,213	$434,770	$78,443
South	Conner	Beatrice	$1,650,742	$1,397,270	$253,472
	Nelson	Arthur	$1,654,297	$1,402,779	$251,519
	Pierce	Charles	$2,084,241	$1,782,276	$301,966
Southeast	Benner	Ian	$520,737	$441,073	$79,664
	Lynch	Sam	$592,471	$503,833	$88,639
	McClain	Sean	$531,371	$453,072	$78,299
	Strome	Fred	$595,372	$505,298	$90,074
Southwest	Bates	Michael	$1,068,907	$904,996	$163,911
	Bell	Caitlin	$1,040,481	$883,441	$157,039
	Hunt	Matthew	$731,413	$619,634	$111,779
	Johnson	Andrew	$445,052	$378,221	$66,831
	Schafer	Rose	$408,280	$346,508	$61,772

Figure 9 - Data filtering interface

8. How important is the education, skills and workforce availability in opening a new high-technology business?

#	Answer		Response	%
1	5 - Very Important		27	93%
2	4		2	7%
3	3		0	0%
5	2		0	0%
6	1 - Not Important		0	0%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.07
Variance	0.07
Standard Deviation	0.26
Total Responses	29

Data and metrics about education, skills and workforce should definitely be included in the list of main metrics shown on dashboard. Today's high-tech businesses have a great share in the economy. For people to gain skills and for a state to gain high performance workforce the state primarily needs good education base. "Excellence in education and educational opportunities for all is the best guarantee of meeting the demands of the global economy.[7]" The answer to this question is supposed to justify the use of Talent Development Metrics as primary index on the dashboard homepage.

[7] http://www.nam.org/Issues/Official-Policy-Positions/Human-Resources-Policy/HRP-01-Education-and-the-Workforce.aspx

9. How important is innovation and entrepreneurship in opening a new high-technology business?

#	Answer		Response	%
1	5 - Very Important		20	74%
2	4		6	22%
3	3		1	4%
5	2		0	0%
6	1 - Not Important		0	0%
	Total		27	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	1.30
Variance	0.29
Standard Deviation	0.54
Total Responses	27

Today's economy is dynamic, globally oriented, collaborative and highly relies on innovation and entrepreneurship which is confirmed by 74% of participants answering that innovation and entrepreneurship is very important in opening a new high-technology businesses.

10. How important are transportation and public infrastructure systems in opening a new high-technology business?

#	Answer		Response	%
1	5 - Very Important		5	17%
2	4		17	59%
3	3		6	21%
5	2		1	3%
6	1 - Not Important		0	0%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	2.14
Variance	0.69
Standard Deviation	0.83
Total Responses	29

From the distribution of answers it can be concluded that the transportation and public infrastructure is not of primary importance to MHTC and therefore corresponding metrics will be reserved for future work.

11. How do you usually find out about tax structures and business climate in one state?

#	Question	You can have multiple answers	Total Responses
1	News Articles	18	18
2	Television	6	6
3	Radio	3	3
4	State dashboards	5	5
5	Government website	16	16
6	I don't usually	3	3
7	Other:	8	8

Other:
Advisors
direct contact with state depts of economic development
other reseach
trade pubs and assn's
My Accountant
consultants
Private information services
partners (accountants,etc.)
I am contacted directly
Lawyer/accountant
paid content--CHH, etc.

Statistic	News Articles	Television	Radio	State dashboards	Government website	I don't usually	Other:
Min Value	1	1	1	1	1	1	1
Max Value	1	1	1	1	1	1	1
Total Responses	18	6	3	5	16	3	12

A great majority of participants use News articles and Government websites. Newspapers are increasingly publishing their articles online because it is cheaper for both publisher and customers, paper is not wasted and the news are easily available in remote locations. It was important to compare the type of media that MHTC board members use to our dashboard which is also website based.

12. What do you consider to be the most efficient tools to visualize and compare data that leads to effective decision making?

#	Question	You can have multiple answers	Total Responses
1	Bar/Column charts	20	20
2	Line charts	15	15
3	Tables	17	17
4	Geographical charts	11	11
5	Bubble charts	8	8
6	Other:	1	1

Other:
it is highly dependent on the question being asked and the availble information
relationship graphs
It really depends on the data type

Table Options

Statistic	Bar/Column charts	Line charts	Tables	Geographical charts	Bubble charts	Other:
Min Value	1	1	1	1	1	1
Max Value	1	1	1	1	1	1
Total Responses	20	15	17	11	8	3

It was important to know which kind of visualizations is used specific to Lobbyists and Data Analysts. The most used visualizations are classical Bar/Column charts and tables. However, in order for the dashboard to be engaging and eye-catching the IQP group will also consider using more exotic visualizations such as Geographical and bubble charts.

5.2 Usability Study

The MATTERS Usability Study was conducted with the goal to improve usability and layout of the MATTERS dynamic dashboard and to make user experience more intuitive. Ideally a usability study would include observing the behavior of user study participants by recording their facial expressions on webcam, voice recording while performing a task or live observation. Due to the budget and time restrictions this small scale usability study was conducted in the form of unattended online survey. The study was taken by twenty nine participants. One would think that twenty nine is too few in order to have useful results, but the optimal number of usability study evaluators seems to be around five. According to Jakob Nielsen's guidelines for heuristic evaluation for the maximum cost-benefit one should use only three to five evaluators since there is a huge overlap in their answers (Figure 10). More important than number of evaluators is to do more usability studies during several iterations of dynamic dashboard development. The MATTERS dashboard was evaluated by only one usability study due to limited time. Targeted users

were WPI undergraduates. According to our study 52% of students spend between 1 and 3 hours online per day while 38% spend more than 3 hours (Figure 11). This result justifies the use of undergraduate students as evaluators since with relatively long times spent online they are experienced with typical dynamic dashboard layout and page hierarchy.

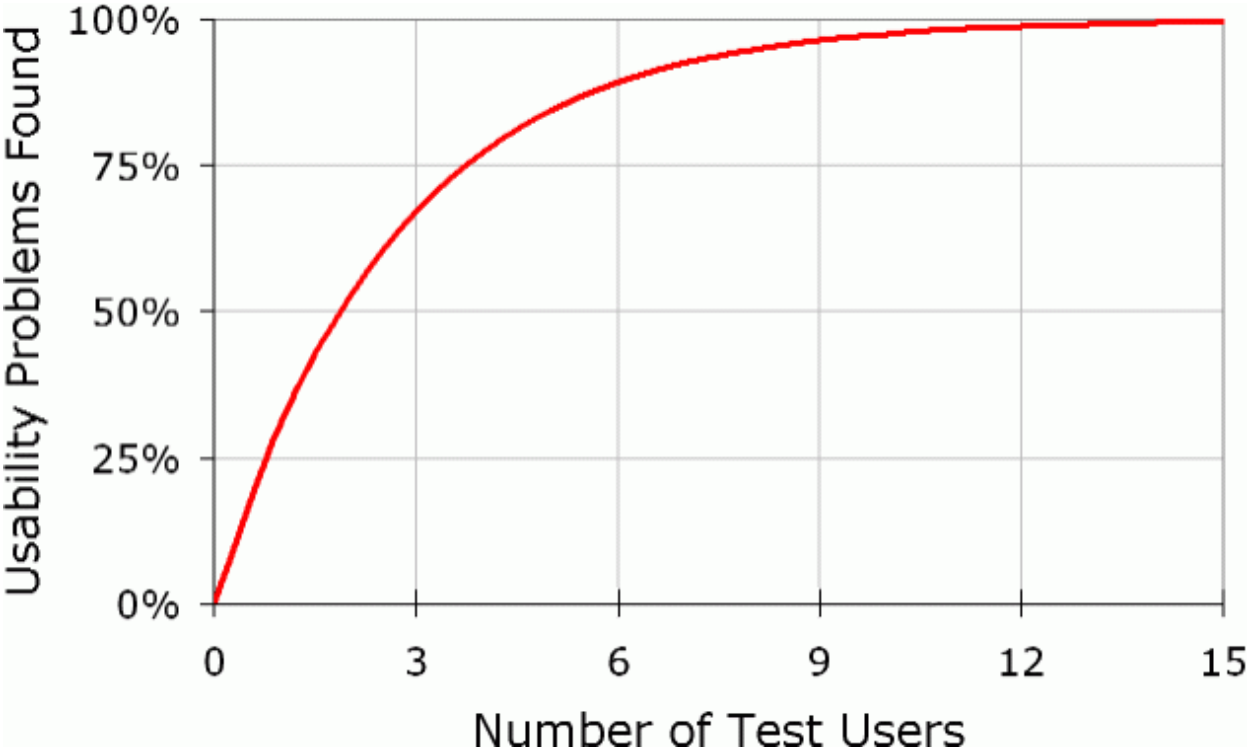


Figure 10 - Why you only need to test with five users[8]

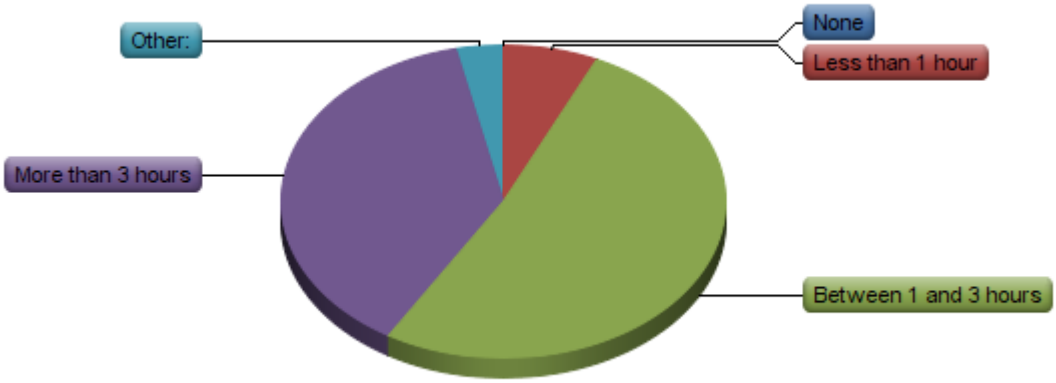


Figure 11 - Study results: How much per day do you spend in surfing the web?

[8] Jakob Nielsen, Why you only need to test with five users (Nielsen Norman Group: 2000)

In addition to that, web browsing abilities of young people have been proven to be closer to the average than that of older people (Panayiotis Zaphiris and Nada Savtich, Age-related Differences in Browsing the Web (City University London, 2008), 2.). Undergraduates in this usability study are 20.58 years old in average.

In an ideal case, the study should not rely on average browsing ability but the browsing ability specific to those who are intended to use the MATTERS dynamic dashboard services, like politicians and lobbyists. However, it is expected that users of MATTERS will be computer literate, therefore undergraduate students represent a target group that has more than enough web browsing knowledge to yield useful results. Panayiotis Zaphiris and Nada Savtich have shown that old and young people have different web browsing abilities. The main reason for different web-page scanning techniques and underlying thought processes that influence decision making is the fact that older people navigate the mouse more slowly which results in fewer number of clicks. In particular, young people skim-read on-screen information and use trial and error approach rather than reading pages thoroughly like older people.

This is the reason for the simplistic layout of the MATTERS dynamic dashboard. One is not supposed to read the instructions to use the dynamic dashboard, but rather try the most intuitive approach to perform a certain task, even if that means trial and error approach.

To investigate what is more intuitive, the users were asked to select the state on the map by its geographical position or to select a state by clicking a button with the state's name. This study has shown that most of the evaluators that is 76% would click on the map rather than having to lookup the state's name through numerous buttons. The rest of 24% of evaluators rated buttons as the best option. However, the use of map on geo-charts assumes that users do know the geographic location of states.

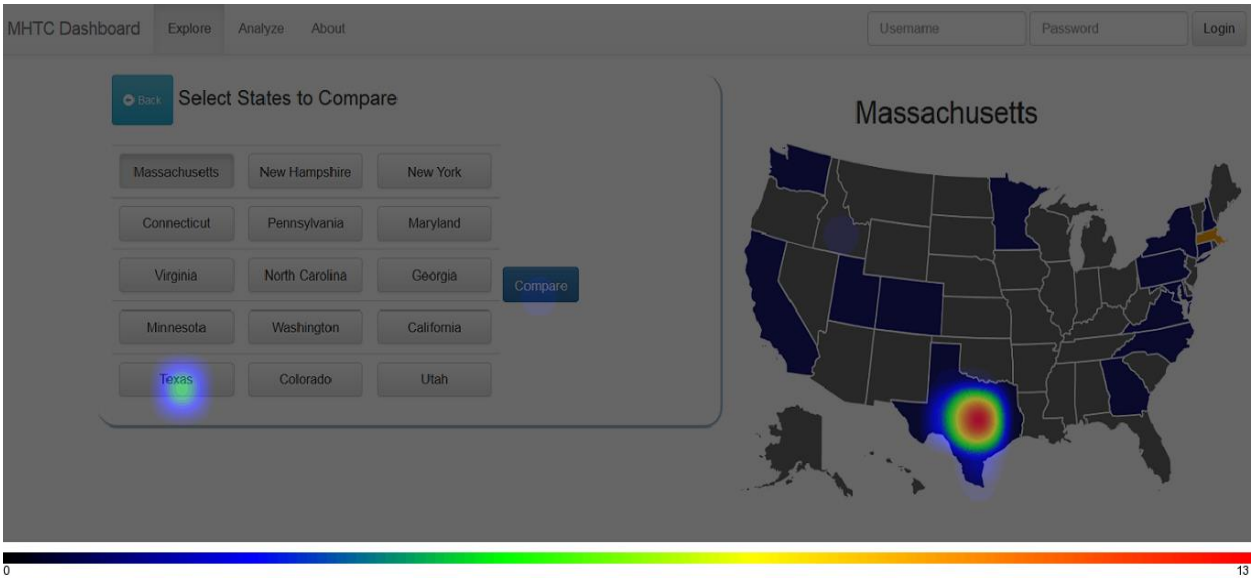


Figure 12 - Heat map showing where evaluators clicked to select state of Texas

In the task/question asked on Figure 12, Texas was deliberately selected as a state with relatively large area. The problem with the geo-chart selection could occur when the states with small areas need to be selected, such as Connecticut. To prove that selecting small states might influence users to switch from map to button selection, the following task/question was asked in the study: "Please click to select the state of Connecticut.

Please use a method of selection that is most convenient to you. If both methods of selection are equally convenient, then click on both." (Figure 13)

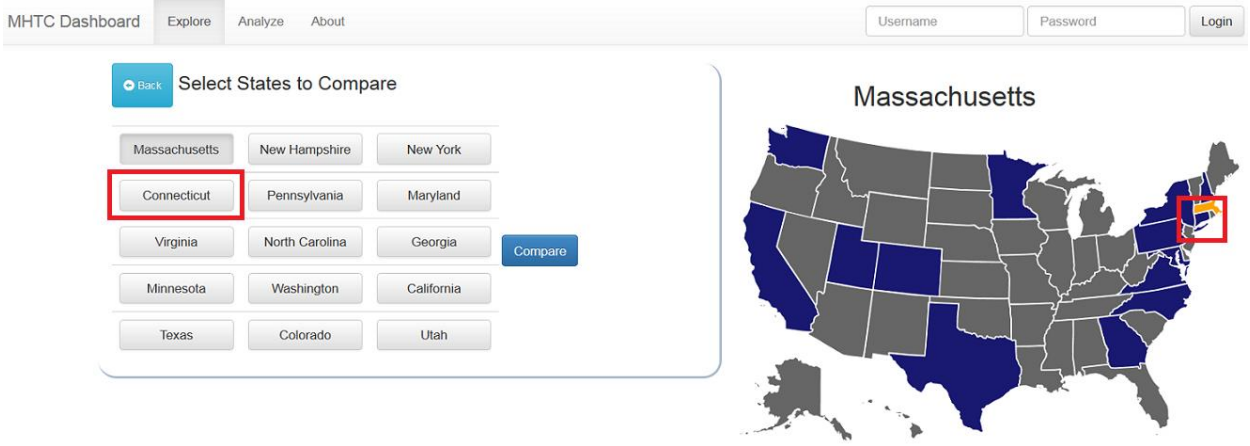


Figure 13 - When selecting small states button selection is more convenient

Indeed in this case 66% of evaluators have chosen to select the button Connecticut while 58% of them choose to select Connecticut on the map. Note that the answers are not mutually exclusive and that evaluators can select both, therefore percentages do not add up to hundred percent. It can be concluded that in case of small state the button would be used slightly more than the map.

In order to position copyright information in the most intuitive way evaluators were asked to click on the location where they expect to find the copyright information. Note that clicks on the "about" button are shown in red due to high concentration as oppose to clicks on the bottom of the page that are dispersed. In spite of high concentration of clicks, "about" button takes only 10.3% of them, while majority of them that is 62.4% are on the bottom of the page which is probably the most usual place for that purpose.

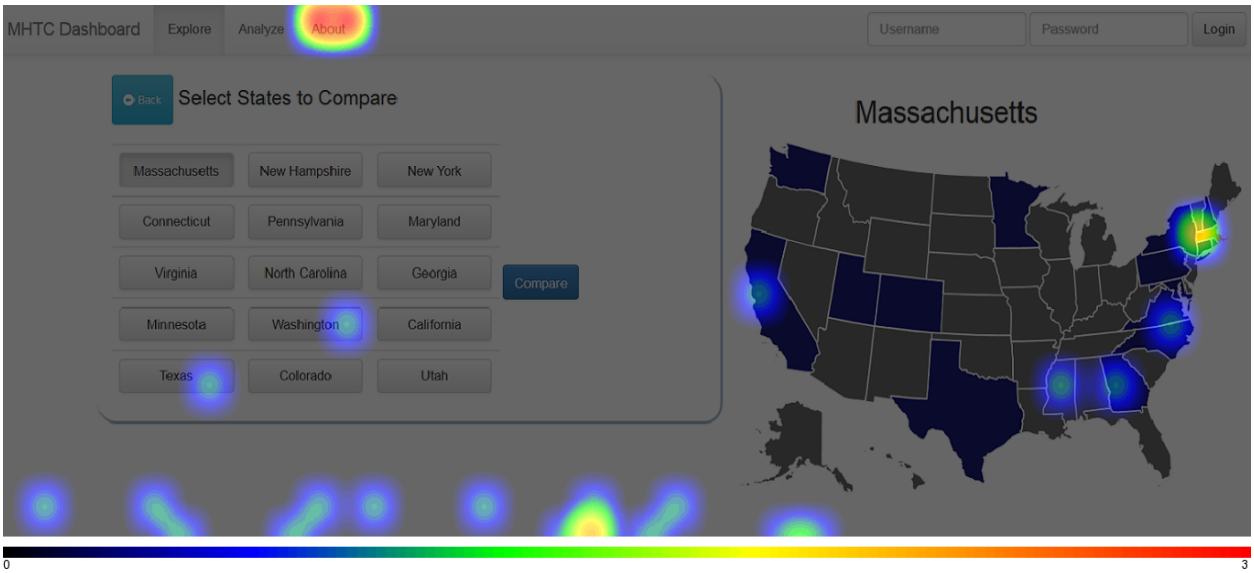


Figure 14 - Heat map showing expected location of copyright information

When asked about which menu type to use, between the two on Figure 15, 83% of evaluators picked the menu that opens with blue check-mark button. This question justified the transition to the new menu design. However, bias might have been introduced through the colors in the overall pictures. The top menu with 86% vote has strong and vibrant colors (red and green trend icons and blue button). The bottom menu with 14% vote has pale green and red colors. Although there might have been some bias on the pictures, the huge difference in the percentages allows a decision to be made in favor of new design (Top menu).

Opens when the blue check-mark button is clicked

Opens when a table row is clicked

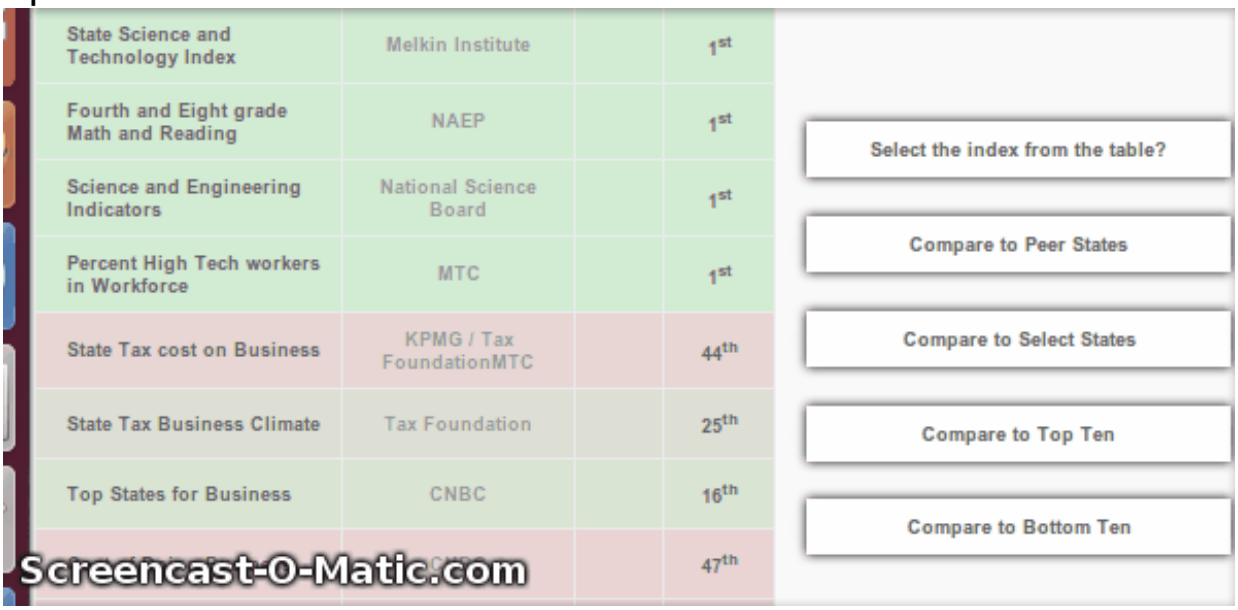


Figure 15 - Two different menu types

The questionnaire also included a test which presented users with the dashboard as we had currently implemented it. However, we had taken screenshots of the major elements of the page (map, grid, and menus) and placed them in their respective locations. Users were prompted to drag elements of the page to the location that they believed they should belong. While many of the users dragged them off the screen or in overlapping positions, we got a few surprising results:

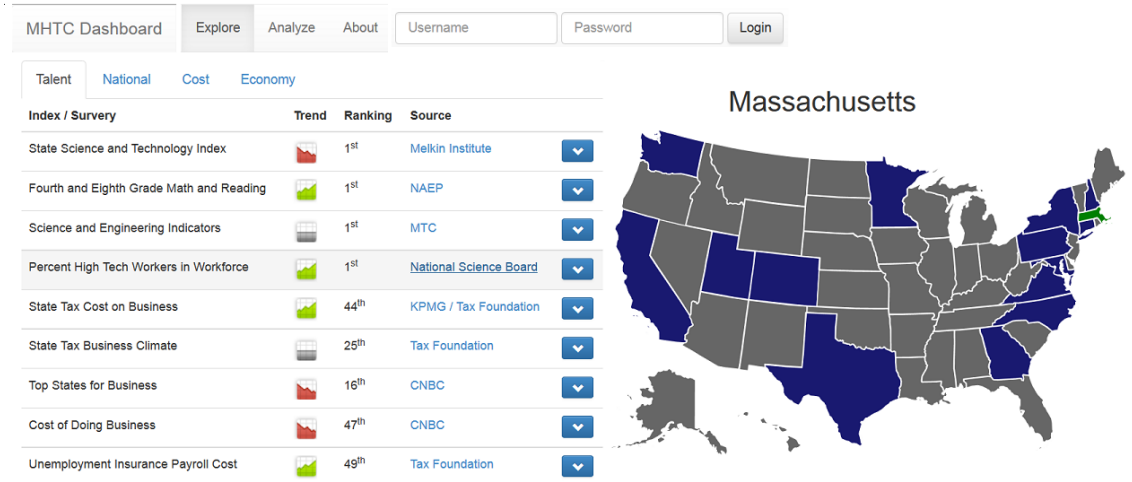


Figure 16 - Default layout

Figure 17 - A user who switched location of map and grid (6 users did this)

Interestingly enough, we only had 5 users pick the default layout, and 3 users who put all the elements in the center stacked on top of each other (which we didn't consider as valid). The drag and drop task/question can be found here[9] and the results of the study can be found here[10].

[9] http://mhtc.cs.wpi.edu
[10] http://mhtc.cs.wpi.edu:page/info

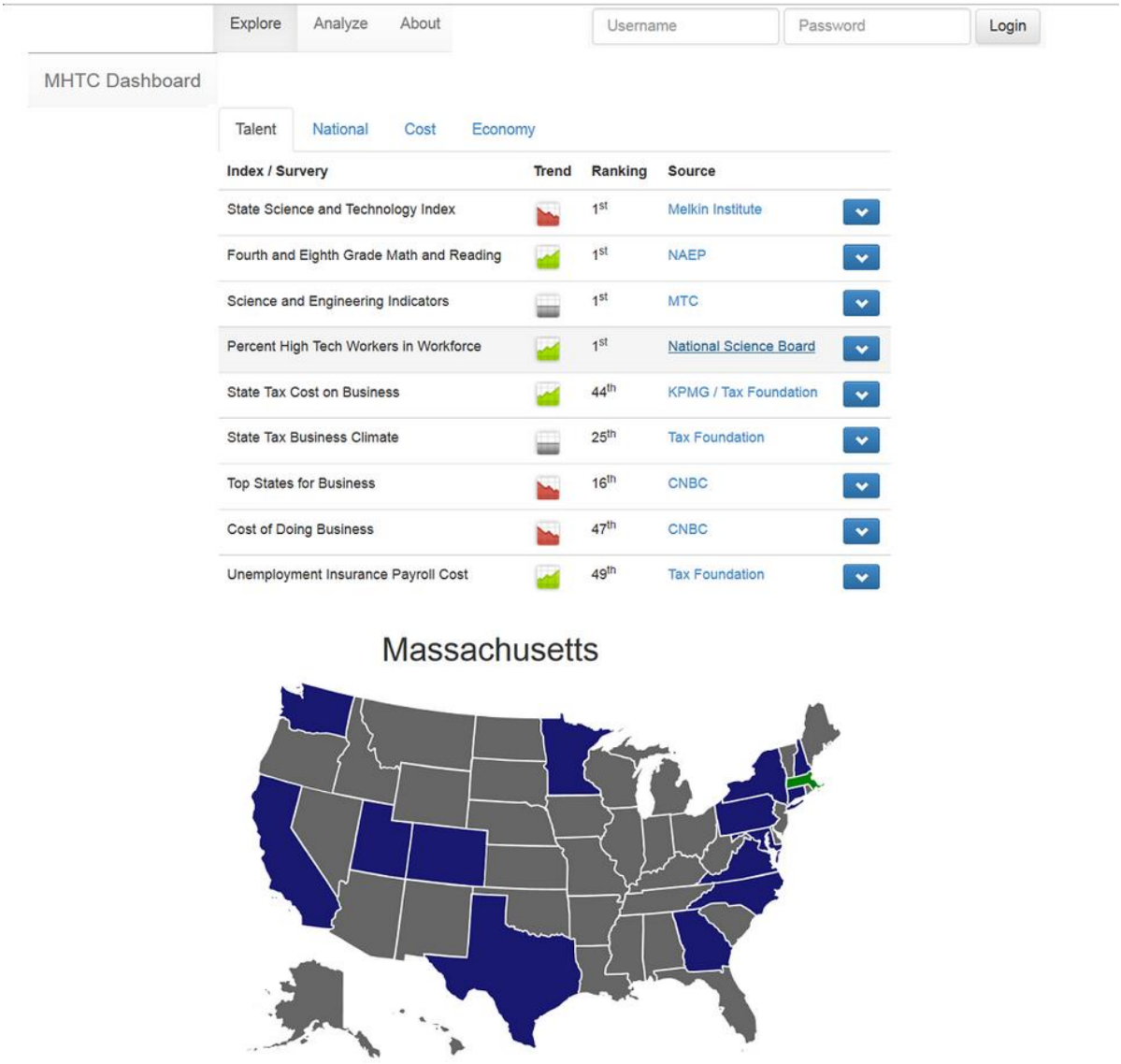


Figure 18 - A user who positioned the map and grid vertically (2 users did this)

The following table shows the comments and suggested improvements. Indeed the IQP group already discussed adding of the map functionality where small states get bigger when hovered with mouse. However, there could be an issue in picking/switching to a single state, where there are several small states in a group. Due to time constraints this option is left open for future improvements.

Another comment suggests adding caption explaining how to interact with the dynamic dashboard. However the websites in its nature are supposed to be intuitive to use and should not require any form of instructions if possible since it will repel the users who want to finish a task fast. This is due to the usual trend where people are served with a lot of unnecessary information and text that has to be avoided by skim reading to quickly reach the wanted page.

Complete text responses are given in the Appendix F, while the table below summarizes only comments related to the dashboard.

Text Response
Maybe make the map get bigger in certain areas when you mouse over. Would be easier to select states that are small that way.
Having two methods of interfacing is probably the best option, as long as other people aren't overwhelmed by it. Just have a caption or such explaining how they interact with the website.
Make the layout easier to navigate and more appealing
The suggested method works fine in its own.
Make it more explicit
It seemed kind of blank and empty...
I would create side margins and center the div so that it does not span edge to edge widthwise.
Add a bit more flair, but no more links or buttons.
I would make it more colorful or more appealing to the eye.
I thought the website was really well layer out. I would highlight my selections on the page and when something is clicked on, highlight it more noticeably.
Regarding the question asking for the user to highlight Connecticut, I think that if the location is familiar to the user, it is more intuitive to select the state on the map, whereas if the location of the state is unfamiliar, the option to select from an alphabetized list would be useful. In situations where the state is very small in comparison to the rest of the country (e.g. Rhode Island) you may want to include either a zoom function (where you could use the scroll wheel on the mouse) or break the region off from the rest of the country and enlarge it. This problem really only occurs for the northeast.

The Figure 19 shows that 41% of evaluators are less experienced and 31% have some experience in web design (Figure 16). This result seems reasonable since the survey was conducted mainly through Electrical and Computer Engineering (~66% of students) and Psychology department (~33% of student), which is expected to yield students with no or some web design experience. However, in general for the usability study purposes having web design experience is not crucial for evaluators. The reason for this short question would be to help in decision making between a potential two options with the same percentage of vote. This would have been done by adding weights to the responses according to evaluator's web design experience to solve the tie result in favor of one option.

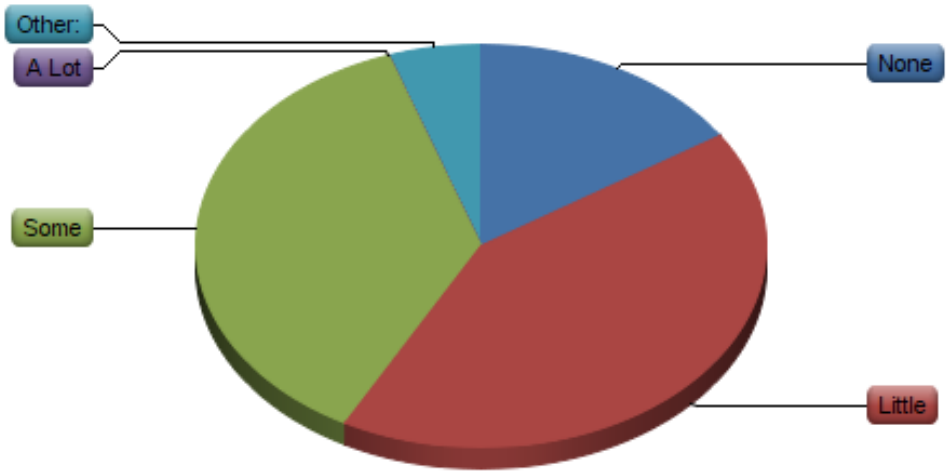


Figure 19 - Pie chart showing how evaluators are experienced with web design

6 Conclusion

The final product, that is, the MATTERS dynamic dashboard was delivered to the MHTC. The IQP group was working in collaboration with other sub-teams, mainly WPI graduate students, in building the dashboard. Other sub-teams were responsible for database, back-end framework and data acquisition system, while the IQP group was responsible for the web interface specifically. WPI owns the copyrights of the dynamic dashboard.

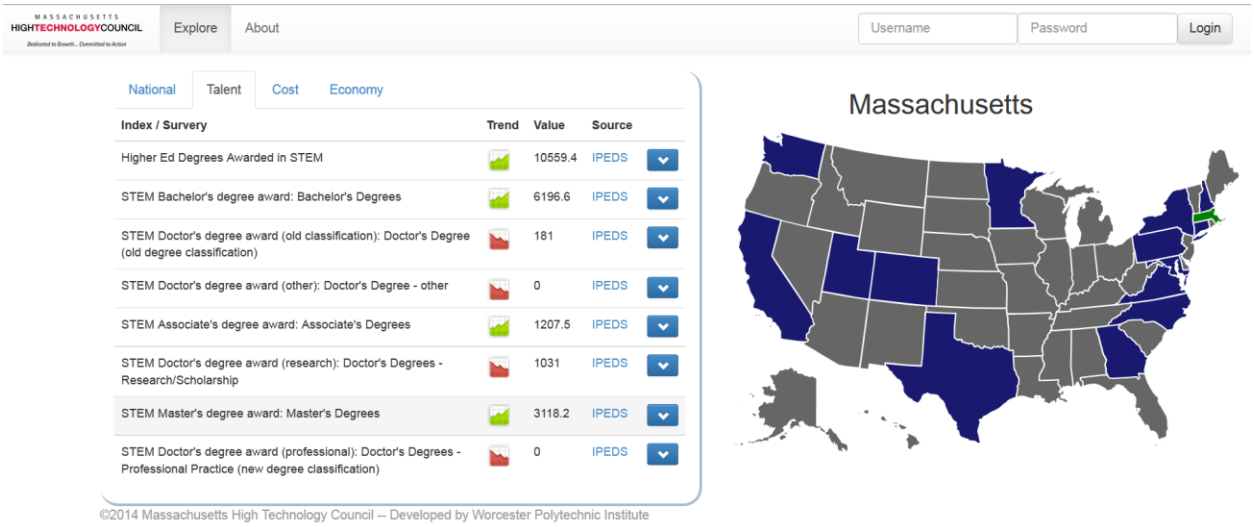


Figure 20 - MATTERS home page

The home page of the MATTERS dynamic dashboard including the feedback from usability study has been implemented as in Figure 20. The copyright information is placed at the bottom of every page. The layout of the page elements did not change from the initial design. According to the usability study both button and map selection methods were kept (Figure 21).

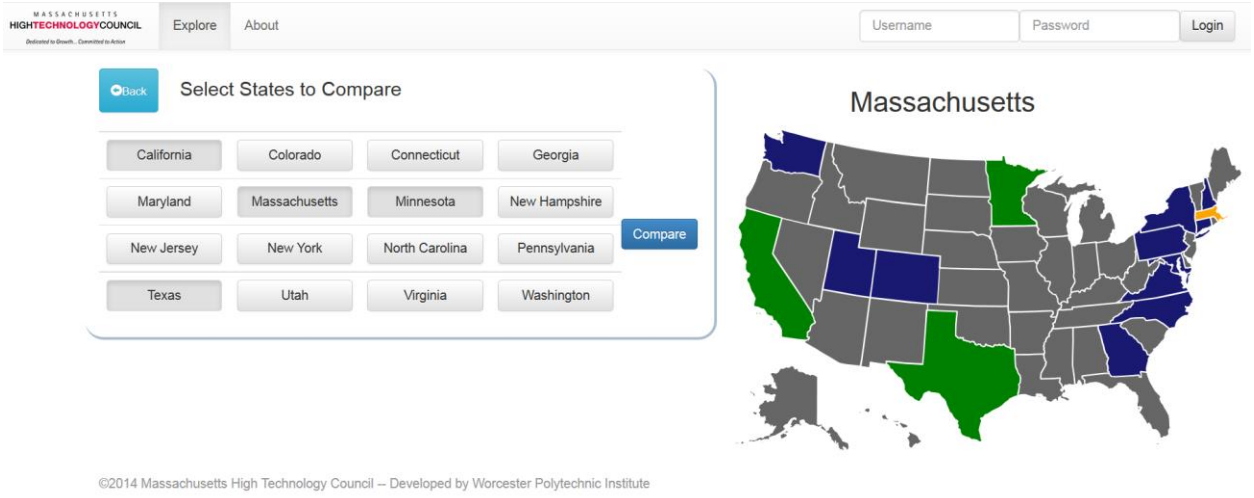


Figure 21 - Select states page

The use of the new menu type was used as its usability was proven by the study. The menu that opens with a blue button contains following functionalities:

- Compare to peer states
- Compare to selected states
- Compare to bottom ten
- Compare to top ten

Figure 22 shows an example graph generated with "Compare to selected states" function. Trend icon was added in each row which indicates whether corresponding metric is in falling, steady or rising trend through time. Also the source of data was listed in each row in order to convince users of data validity. The MATTERS dynamic dashboard can be found on the following URL: http://mhtc.cs.wpi.edu:8080/mhtc/# (subject to change at the moment of writing)

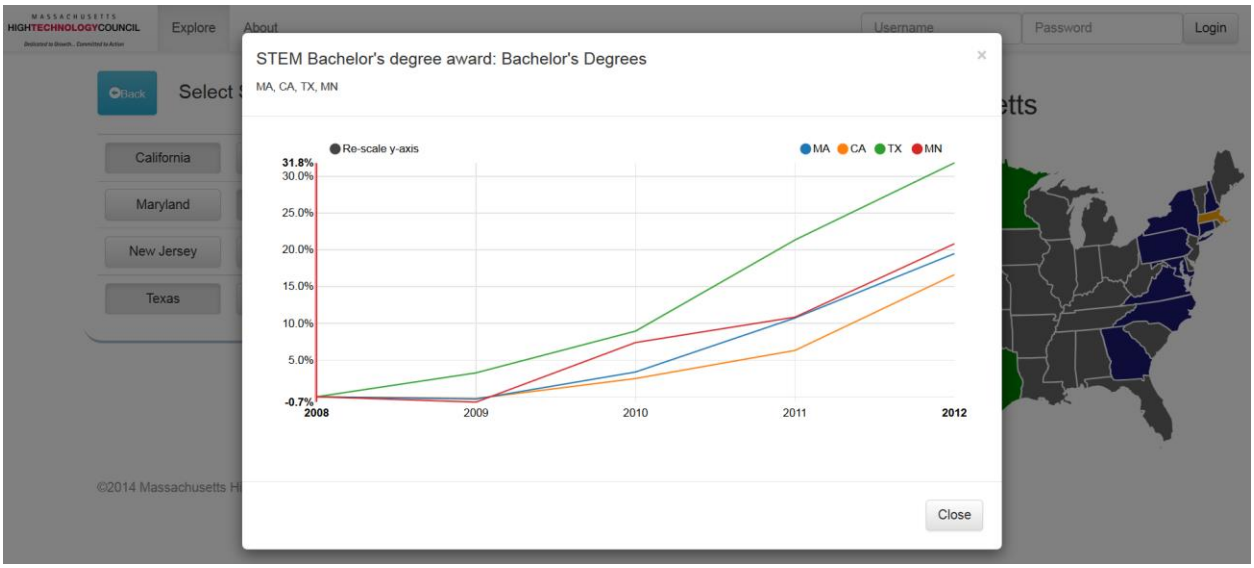


Figure 22 - Graph generated from select states page

The summarized result from MHTC survey that affects the MATTERS dynamic dashboard is on the Figure 23. The graph shows that MHTC board members would mostly use bar charts, line charts and tables, specifically in their field of expertise. The current version of the MATTERS uses line charts and tables. Bar charts are left for future improvements to other potential projects with WPI-MHTC collaboration.

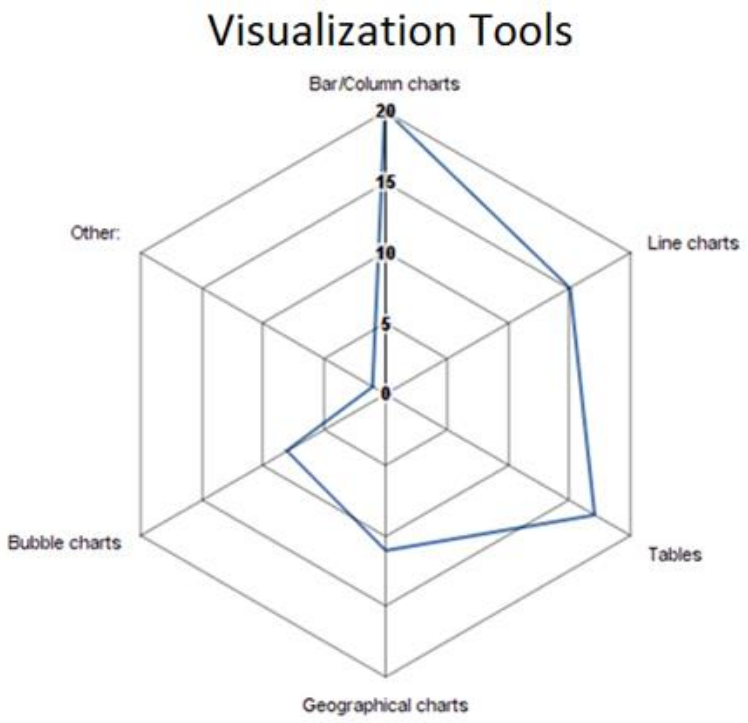


Figure 23 - Visualization tools

7 Appendix A

Human Capital Investment metrics:

• All Recent Degrees in Science and Engineering per 1,000 Civilian Workers (2010)
• Average ACT Scores (2011)
• Average Math SAT Scores (2011)
• Average Verbal SAT Scores (2011)
• Number of Doctoral Engineers per 100,000 People (2008)
• Number of Doctoral Scientists per 100,000 People (2008)
• Percent Change in State Appropriations for Higher Education (2010-2011)
• Percentage of Bachelor's Degrees Granted in Science and Engineering (2009)
• Percentage of Graduate Students (Ages 25 - 34) in Science, Engineering, and Health (2007)
• Percentage of Households with Computers (2003)
• Percentage of Households with Internet Access (2009)
• Percentage of Population Age 25+ with Bachelor's Degree or Higher (2011)
• Percentage of Population Ages 25+ with Advanced Degrees (2011)
• Percentage of Population Ages 25+ with PhDs (2011)
• Recent Bachelor's Degrees in Science and Engineering per 1,000 Civilian Workers (2010)
• Recent Master's Degrees in Science and Engineering per 1,000 Civilian Workers (2010)
• Recent PhDs in Science and Engineering per 1,000 Civilian Workers (2010)
• Science, Engineering, and Health PhDs Awarded per 100,000 People Ages 25 - 34 (2008)
• Science, Engineering, and Health Post doctorates Awarded per 100,000 People Ages 25 - 34 (2007)
• State Appropriations for Higher Education, Per Capita (2011)
• State Spending on Student Aid, Per Capita (2010-2011)

8 Appendix B

Risk Capital and Entrepreneurial Infrastructure metrics:

• Average Annual SBIC Funds Disbursed per $1,000 of GSP (2008-2010)
• Increase in Number of Companies Receiving VC Investment (2010-2011)
• IPO Proceeds as Percent of GSP (2009-2011)
• Number of Business Incubators per 10,000 Business Establishments (2011)
• Number of Business Starts per 100,000 People (2010)
• Number of Companies Receiving VC Investment per 10,000 Business Establishments (2000-2011)
• Patents Issued per 100,000 People (2011)
• Sum of Equity Invested in Green Tech per 100,000 GSP (2011)
• Total Venture Capital Investment Growth (2010-2011)
• VC Investment in Clean Technology per $1,000 of GSP (2008-2011)
• VC Investment in Nanotechnology per $1,000 of GSP (2008-2011)
• Venture Capital Investment as Percent of GSP (2011)

9 Appendix C

Research and Development Input metrics:

• Academic R&D Dollars per Capita (2009)
• Average Annual Number of SBIR Awards per 100,000 People (2008-2010)
• Average Annual Number of STTR Awards per 10,000 Business Establishments (2008-2010)
• Average STTR Award Dollars per $1 Million of GSP (2008-2010)
• Competitive NSF Proposal Funding Rate (2011)

• Federal R&D Dollars per Capita (2009)
• Industry R&D Dollars per Capita (2009)
• National Science Foundation Funding per $100,000 of GSP (2011)
• National Science Foundation Research Funding per $100,000 of GSP (2011)
• R&D Expenditures on Agricultural Sciences, US$ per Capita (2010)
• R&D Expenditures on Biomedical Sciences, US$ per Capita (2010)
• R&D Expenditures on Engineering, US$ per Capita (2010)
• R&D Expenditures on Environmental Sciences, US$ per Capita (2010)
• R&D Expenditures on Life Sciences, US$ per Capita (2010)
• R&D Expenditures on Math and Computer Sciences, US$ per Capita (2010)
• R&D Expenditures on Physical Sciences, US$ per Capita (2010)
• SBIR Awards per 10,000 Business Establishments, Phase I (2010)
• SBIR Awards per 10,000 Business Establishments, Phase II (2010)

10 Appendix D

Technology and Science Work Force Composite Index metrics:

• Intensity of Agricultural and Food Scientists per 100,000 Civilian Workers (2011)
• Intensity of Agricultural and Food Scientists per 100,000 Civilian Workers (2000)
• Intensity of Agricultural Engineers per 100,000 Civilian Workers (2001)
• Intensity of Biochemists and Biophysicists per 100,000 Civilian Workers (2006)
• Intensity of Biomedical Engineers per 100,000 Civilian Workers (2008)
• Intensity of Computer and Information Scientists per 100,000 Civilian Workers (2011)
• Intensity of Computer and Information Scientists per 100,000 Civilian Workers (2000)
• Intensity of Computer Hardware Engineers per 100,000 Civilian Workers (2001)

• Intensity of Computer Programmers per 100,000 Civilian Workers (2006)
• Intensity of Computer Support Specialists per 100,000 Civilian Workers (2008)
• Intensity of Computer Systems Analysts per 100,000 Civilian Workers (2011)
• Intensity of Computer Systems Analysts per 100,000 Civilian Workers (2000)
• Intensity of Database and Network Administrators per 100,000 Civilian Workers (2001)
• Intensity of Electrical Engineers per 100,000 Civilian Workers (2006)
• Intensity of Electronics Engineers per 100,000 Civilian Workers (2008)
• Intensity of Medical Scientists per 100,000 Civilian Workers (2011)
• Intensity of Medical Scientists per 100,000 Civilian Workers (2000)
• Intensity of Microbiologists per 100,000 Civilian Workers (2001)
• Intensity of Other Engineers per 100,000 Civilian Workers (2006)
• Intensity of Other Life and Physical Science Occupations per 100,000 Civilian Workers (2008)
• Intensity of Physicists per 100,000 Civilian Workers (2011)
• Intensity of Physicists per 100,000 Civilian Workers (2000)
• Intensity of Software Engineers, Systems Software per 100,000 Civilian Workers (2001)

11 Appendix E

Technology Concentration and Dynamism metrics:

• Average Yearly Growth of High-Tech Industries (2007-2011)
• Average Yearly Growth of High-Tech Industries (1996-2000)
• Net Formation of High-Tech Establishments per 10,000 Business Establishments (1999)
• Number of High-Tech Industries Growing Faster than U.S. Average (2002-2006)
• Number of High-Tech Industries with LQ Higher than 1.0 (2008)

• Number of Inc. 500 Companies per 10,000 Business Establishments (2012)
• Number of Inc. 500 Companies per 10,000 Business Establishments (2000)
• Number of Technology Fast 500 Companies per 10,000 Business Establishments (2001)
• Percent of Employment in High-Tech NAICS Codes (2006)
• Percent of Establishment Births in High-Tech NAICS Codes (2006)
• Percent of Establishments in High-Tech NAICS Codes (2010)
• Percent of Establishments in High-Tech NAICS Codes (1998)
• Percent of Payroll in High-Tech NAICS Codes (1999)

12 Appendix F – Usability Study Report

Report Last Modified: 05/06/2014

1. Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. To move to the next task, please click on arrow button in the lower right corner.

#	Answer		Response	%
1	Agree		41	98%
2	Disagree		1	2%
	Total		42	100%

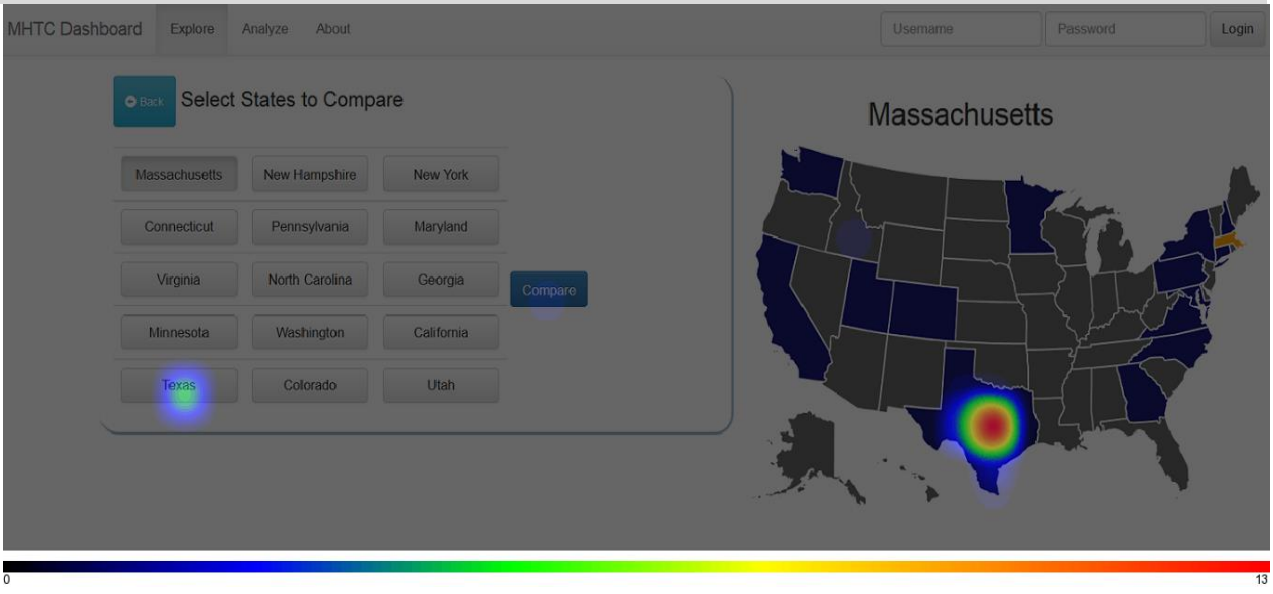
Statistic	Value
Min Value	1
Max Value	2
Mean	1.02
Variance	0.02
Standard Deviation	0.15
Total Responses	42

2. In this question you will be asked to complete a task. In this process, a new tab will open in your browser for you to complete a task. Once you complete the task, please hit "SAVE". After that, please return to the last tab which contains the actual survey. Furthermore, if there are any general comments or feedback that you would like to provide, type those comments into the text box below. To conduct the current task, please follow this link now. Comments box:

Text Response
if a tree falls in the forest and nobody is around to hear it, would this survey help answer the question?
Put the list under the map

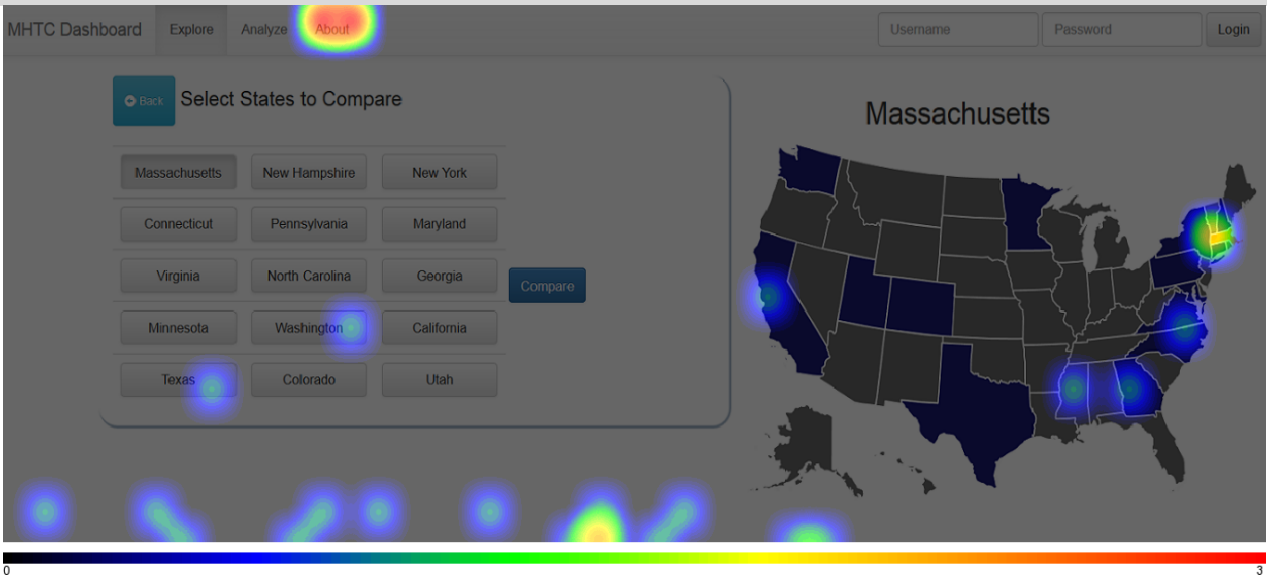
Statistic	Value
Total Responses	2

3. Please click to select the state of Texas. Please use a single method of selection that is most intuitive to you.



Statistic	Value
Total Responses	29

4. Please click on the location on the web page, where you would expect to find the copyright information.



Statistic	Value
Total Responses	29

5. Click on the respective radial button to indicate which menu type you prefer for opening the analytics options.

#	Answer		Response	%
1	Opens when the blue check-mark button is clicked		25	86%
2	Opens when a table row is clicked		4	14%
	Total		29	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.14
Variance	0.12
Standard Deviation	0.35
Total Responses	29

6. Please click to select the state of Connecticut. Please use a method of selection that is most convenient to you. If both methods of selection are equally convenient, then click on both.

#	Question	Off	On	Total Responses	Mean
29	Map #2	12	17	29	1.59
31	Button #1	10	19	29	1.66

Statistic	Map #2	Button #1
Min Value	1	1
Max Value	2	2
Mean	1.59	1.66
Variance	0.25	0.23
Standard Deviation	0.50	0.48
Total Responses	29	29

7. What did you like about the website?

Text Response
It's pretty interesting
Nothing in particular.
looked cool
Easy to navigate once you understand how the interface works (2 seconds of thought)
the USA
It was easy to use
The layout and map
it had a map and other options
the state was highlighted
The layout and theme made the easy to view and progress around.
The simplicity
I liked how it was interactive.
It was visually appealing and attractive to the eye
I liked the layout of the map next to the selections, with shading.
The components of the site, regardless of layout, were aesthetically pleasing and seemed intuitive to use

Statistic	Value
Total Responses	16

8. What did you dislike about the website?

Text Response
Nothing in particular.
the map.
Obviously not very efficient for selecting small states.
russia
Needs to be better organized
It had 'MERICA in it
The content - it was confusing
it was too white
the state itself was too small
I had no idea where the bottom of the website was.
Maybe a bit bland
It was a bit confusing.
It was cluttered
I disliked the amount of room the list of states took up, possibly arrange them in a scroll down bar so you have more interface room.
Nothing that I could tell from the questions asked.

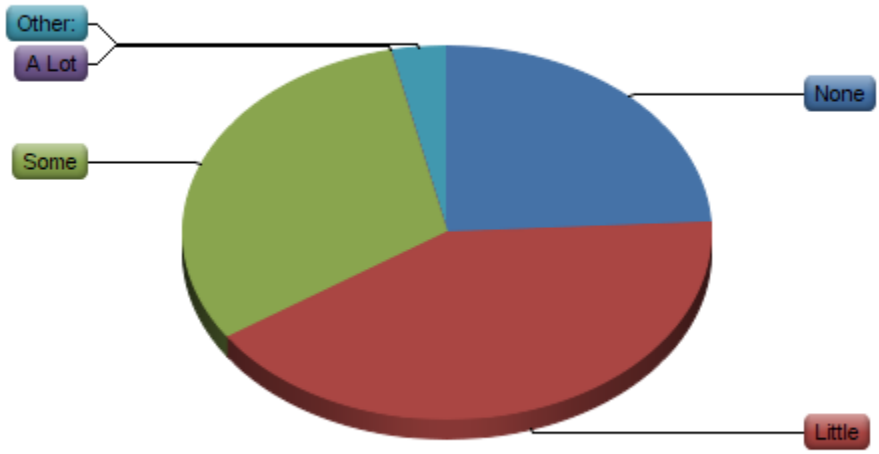
Statistic	Value
Total Responses	15

9. Any other comments about the website? How would you improve it?

Text Response
maybe make the map get bigger in certain areas when you mouse over. would be easier to select states that are small that way.
Having two methods of interfacing is probably the best option, as long as other people aren't overwhelmed by it. Just have a caption or such explaining how the interact with the website.
if a parking ticket was placed on your windshield for a parking violation that you in fact did violate, does it make it ok to rip it up and say you never got it and confess it on this survey?
Make the layout easier to navigate and more appealing
Add some freedom, throw in liberty and mention patriotism
The suggested method works fine in its own.
Make it more explicit
It seemed kind of blank and empty...
I would create side margins and center the div so that it does not span edge to edge widthwise.
Add a bit more flair, but no more links or buttons.
I would make it more colorful or more appealing to the eye.
I thought the website was really well layer out. I would highlight my selections on the page and when something is clicked on, highlight it more noticeably.
Regarding the question asking for the user to highlight Connecticut, I think that if the location is familiar to the user, it is more intuitive to select the state on the map, whereas if the location of the state is unfamiliar, the option to select from an alphabetized list would be useful. In situations where the state is very small in comparison to the rest of the country (e.g. Rhode Island) you may want to include either a zoom function (where you could use the scroll wheel on the mouse) or break the region off from the rest of the country and enlarge it. This problem really only occurs for the northeast.

Statistic	Value
Total Responses	13

10. How experienced are you with website design?

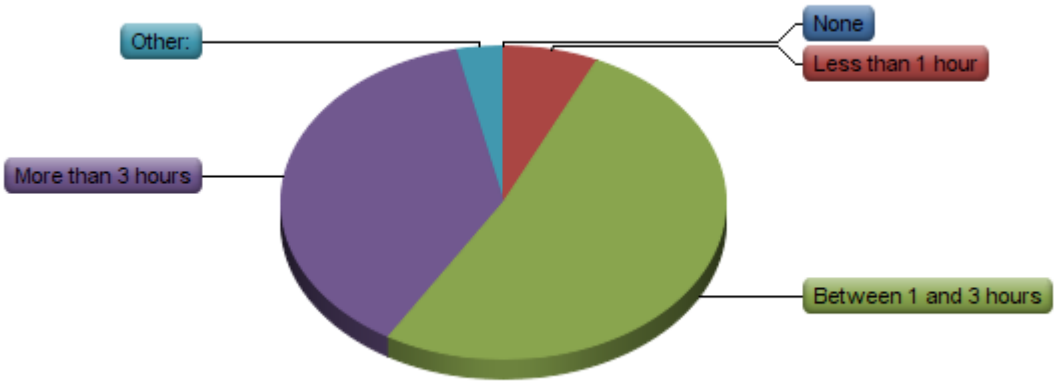


#	Answer		Response	%
12	None		7	24%
13	Little		12	41%
14	Some		9	31%
15	A Lot		0	0%
16	Other:		1	3%
	Total		29	100%

Other:
all of the above

Statistic	Value
Min Value	12
Max Value	16
Mean	13.17
Variance	0.86
Standard Deviation	0.93
Total Responses	29

11. In average how much time per day do you spend in surfing the web?



#	Answer		Response	%
4	None		0	0%
5	Less than 1 hour		2	7%
6	Between 1 and 3 hours		15	52%
7	More than 3 hours		11	38%
8	Other:		1	3%
	Total		29	100%

Other:
a&d

Statistic	Value
Min Value	5
Max Value	8
Mean	6.38
Variance	0.46
Standard Deviation	0.68
Total Responses	29

12. What is your age?

Text Response
20
20
22
20
21
21
22
22
21
20
21
19
20
19
23
21
0
20
19
19
20
22
20
19
19
21
24

Statistic	Value
Total Responses	27

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