Students in Need of an Attitude Adjustment?

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Questions & Answers

How has statistics been used in the last 24 hours and has it been used properly?

- "Right now with the NCAA brackets being filled out everyone is using statistics to show who they think will win. Although I believe they are trying to use it properly, I do think that there is a lot of bias going on!"
- "I was working on a sociology assignment and found an article describing increasing breast cancer rates in young women. It explained how they used hypothesis testing, p-values and other things we have learned in class! I thought it was cool to see it put to use in real life!"
- "I saw statistics being used on TV for an infomercial and it said something like 98% of people saw results. However, I don't think that was used properly."

"Home births give babies a good chance" was a headline in the NZ Herald in 1990. The article then went on to report that babies are twice as likely to die during or sooner after a hospital delivery than from a home birth. The report was based on a random sample of home births and hospital births. Does this mean hospitals are dangerous places to have babies in Australia?

- "No because if you are having a baby at home you are less high risk than someone who is having a baby in a hospital. Other circumstances may be that the mothers could be having the baby prematurely or the baby is faced with medical problems at the time of birth. Overall, it doesn't mean you are more high risk."
- "Not necessarily, it depends on the circumstances. The woman's health, age, and how early or late the baby is due to her term. Many women would opt for hospital births when they are in more risky or emergency situations versus not having any problems and having the child in the safety of your own home."
- "No. This report is focusing on one variable, home or hospital, not taking the time to consider the nature of the birth. Most people with problems beforehand will go to the hospital, or ones with severe complications will get rushed to the hospital. These statistics are biased."

Motivation & Design

Getting students interested in learning statistics and appreciating its value is a challenging task. The authors considered the following questions:

- Is there a way to show students (or increase) the value of what they are learning?
- Can something be done to increase student interest without increasing teacher burden?
- What are students interested in?

The authors implemented a Question of the Day which is given to students at the start of each class and involves statistics in some way.

A total of three algebra-based introductory statistics courses were used - one from WSU and two from NKU (one a "control" group and the other an experimental group). In addition, students were asked to complete the Students' Attitude Toward Statistics (SATS) at the beginning, middle, and end of semester.

What is SATS?

Schau and Bond created a tool for measuring students' attitudes towards statistics called the SATS © survey (Schau 2003). The survey measures students' attitudes in six key areas:

Affect
students' feelings concerning statistics

Cognitive Competence
students' attitudes about their intellectual knowledge and skills when applied to statistics

Value
students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life

Difficulty
students' attitudes about the difficulty of statistics as a subject

Interest
students' level of individual interest in statistics

Effort
amount of work the student expends to learn statistics

Beginning and Mid Semester Results

Section	Survey	Affect	Cognitive	Value	Difficulty	Interest	Effort
"Control" at NKU (n=18)	Beginning	4.337	4.62	4.741	3.542	4.986	6.472
	Mid-Semester	4.596	5.12	4.813	3.738	4.778	6.22
	Difference (Mid-Beg)	**0.259**	**0.5**	**0.072**	**0.196**	**-0.208**	**-0.252**
Experimental at NKU (n=22)	Beginning	3.877	4.72	4.782	3.252	4.557	6.306
	Mid-Semester	4.302	5.014	4.711	3.42	4.212	6.489
	Difference (Mid-Beg)	**0.425**	**0.294**	**-0.071**	**0.168**	**-0.345**	**0.183**
Experimental at WSU (n=32)	Beginning	4.267	4.688	5.081	3.738	4.500	6.750
	Mid-Semester	4.663	5.136	4.840	4.026	4.164	6.490
	Difference (Mid-Beg)	**0.396**	**0.448**	**-0.241**	**0.288**	**-0.336**	**-0.260**

Comments

After implementing the Question of the Day in the spring 2013 semester the following changes are being considered for implementation in the fall 2013 semester:

- Change to Question of the Week allowing students to put more thought into their responses.
- Adjust topics to be more relatable to students as well as more current events.
- Adjust timing of question topics to better coincide with the material being covered at that time.
- Make questions more detailed to give students a little more guidance.

WSU student comments to the question:

"What suggestions do you have to make the Question of the Da y more relevant to the course material?"

- "Ask questions about situations relatable to the students in the class. Things that are taking place now."
- "None, they were good at picking our brains."
- "They are pretty relevant to everyday life."

References

Schau, Candace, and Esma Emmioğlu. "Do Introductory Statistics Courses in the United States Improve Students' Attitudes?" *Statistics Education Research Journal, Vol. 1, 2 Nov 2012.*

Schau, C. (2003a). *Survey of Attitudes Toward Statistics (SATS-36).* [Online: http://evaluationandstatistics.com/]

The Undergraduate Statistics Program of the Future

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MOTIVATION

Continue to develop appropriate curriculum guidelines for an undergraduate statistics program

Ensure that outcomes are adequate for preparing students for employment and/or graduate school

The enormous growth in the amount of data and its potential effects on the global economy is well documented. Nie (2011) suggests that data scientists, who uncover and communicate meaningful insight, be part of a team to go boldly in the direction of "Big Analytics." He mentions this opportunity is enormous and without precedent.

Years Since	Author	Statement
?	?	Suggests training undergraduates is necessary to meet the demands of industry
?	?	"As business and industry become more complex executives will depend more and more on scientific statistical methods for collecting, analyzing, and interpreting information for decision-making."
?	?	Recognizes the need for training statisticians at the undergraduate level and proposes a curriculum
?	?	Urges the assessment and improvement of the statistics curriculum at the undergraduate level
?	?	"Our future depends on achieving a more prominent place in undergraduate education beyond the first methods course."
?	?	Learning outcomes should include the ability to communicate to nontechnical audiences, work as a team, and integrate information from numerous sources

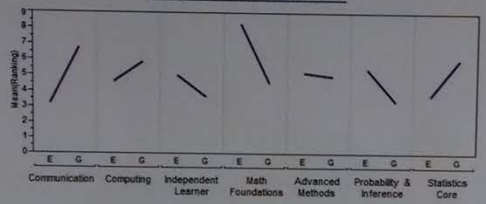
NEED FOR A NEW DEGREE

	Reasons for Changing Degree
Past Curriculum	Current degree hasn't changed much in over 50 years Current degree is designed for students going to graduate school, but not necessarily for those seeking employment
Recruiting	Need a program which will attract more students and a wider variety of students Need a degree which is well-aligned with employers' needs, making graduates more marketable
Skill-set	Need a program which cultivates intellectual curiosity and problem solving skills Today's jobs require more emphasis on skills such as strong communication, familiarity with big data/databases, and object-oriented programming
Growth	There will be tremendous growth in the amount of global data generated every year "Armed with the advantages of Big Data, advanced computing hardware, …, the potential impact of Big analytics is not trivial." (Nie 2011)

PILOT STUDY DESCRIPTION

We recently interviewed 19 representatives from healthcare, manufacturing, retail, and product distribution sectors of industry regarding the desired characteristics of entry level candidates. In addition, a total of 34 individuals from industry and academia ranked a total of 10 program outcomes separately for employment (E) and graduate school (G). A ranking of 1 meant most important and a ranking of 10 meant least important.

WHAT WE'VE LEARNED



	Description of Program Outcome
Communication (2 items)	Effectively communicate with technical and non-technical audiences
Computing	Utilize statistical software packages and algorithms for data management and analyses
Independent Learner	Be an independent learner
Math Foundations (2 items)	Demonstrate an understanding of calculus, linear algebra, methods of proofs and analysis
Advanced Methods (2 items)	Demonstrate an understanding of statistical modeling, study design, multivariate, sampling, categorical, etc.
Probability & Inference	Demonstrate an understanding of probability and statistical inference
Statistics Core	Demonstrate the ability to use statistical methodology in an application

Program Outcome Ranking Results:

- Communication appears to be much more important for employment (avg. rank = 3.19) than for graduate school (avg. rank = 6.77).
- As expected, a solid background in math foundations is needed for students going to graduate school (avg. rank = 4.53), but is not nearly as important for students seeking employment (avg. rank = 8.31).
- The program outcome rankings for the industry representatives and those in academia showed very similar patterns.
- One program can't effectively train students for both graduate school and employment.

Through interviews with industry representatives the following desired characteristics of an entry level candidate were identified. The authors believe the current curriculum does not sufficiently address these industry expectations.

	Desired Characteristics of Ideal Entry Level Candidates
Critical Thinking	Ability to problem solve, think critically, and reason statistically
Communication	Communication and teamwork – ability to convey results to technical and non-technical audiences
Computing	Experience with big data, an object-oriented programming language, and database management tools Exposure to non-structured data and cloud computing
Interdisciplinary	Interdisciplinary background which fosters contextual understanding

ANTICIPATED DATA ANALYTICS DEGREE

While the existing statistics curriculum successfully prepares students for graduate school, a different set of skills is necessary for students seeking employment. As a result, the authors are proposing the following degree as an additional option for those seeking employment.

Statistics (15 credits)	**Communication (6 credits)**
Introductory Course Applied Statistics Core (2 courses) Advanced Methods (2 courses)	Statistical Consulting & Communication Capstone/Internship
Computing (12 credits)	**Mathematics (6 credits)**
Programming & Algorithms I Data Management Data Summarization & Visualization Predictive Analytics	Applied Calculus or Calculus I Matrix Algebra or Linear Algebra
Elective Themes (12 credits)	
Computer Science	**Health Care**
Programming & Algorithms II Database/Data Structures Bioinformatics Web Programming	Science Core Bioinformatics Healthcare Management Medical Terminology
Business	**Statistics**
Management Marketing Finance/Economics MIS	Probability & Statistics Theory Advanced Statistical Methods Mathematics

The anticipated data analytics degree will address the desired characteristics of ideal entry level candidates in the following manner.

	Promoting the Desired Characteristics
Critical Thinking	Utilize more open-ended assessments Provide more client/consultant type interactions Incorporate more inquiry-based teaching methods
Communication	Promote more writing for technical and non-technical audiences Require at least one presentation in each class Require a departmental seminar or conference presentation
Computing	Develop new courses to address: big data database management tools predictive analytics tools
Interdisciplinary	Reduce technical training in mathematics and statistics which will allow for more emphasis on interdisciplinary content
Other	Require more independent learning experiences Promote interactions with professionals from industry Develop professionalism

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Raising Calculus to the Surface

Aaron Wangberg, Winona State University
Jason Samuels, City University of New York - Borough of Manhattan Community College
Eric Weber, Oregon State University
Brian Fisher, Pepperdine University

Discovering Concepts

The new mathematical concepts introduced in multivariable calculus often obscure the major ideas of *change* and *accumulation* from first semester calculus. This alternative approach utilizes tangible surfaces and short exploration activities designed to help students discover the mathematical concepts needed to solve rate and accumulation problems - and how these concepts are so nicely packaged in new quantities like gradient vectors and partial derivatives.

Geometric Reasoning comes first!

Challenge: *Describe how to find the local minima of the function f on the right.*

Which items from the list below did you use?

- Where the function is flat.
- The function is concave down.
- Flat along the boundaries

$\vec{\nabla} f = 0$

$\frac{\partial^2 f}{\partial x^2}\frac{\partial^2 f}{\partial y^2} - \frac{\partial^2 f}{\partial x \partial y}\frac{\partial^2 f}{\partial x \partial y} > 0$

$\frac{\partial f}{\partial \vec{n}}|_{\vec{r}=\vec{s}(s)} = 0$

With geometric reasoning, students develop a plan and implement it using the appropriate algebraic and formulaic objects.

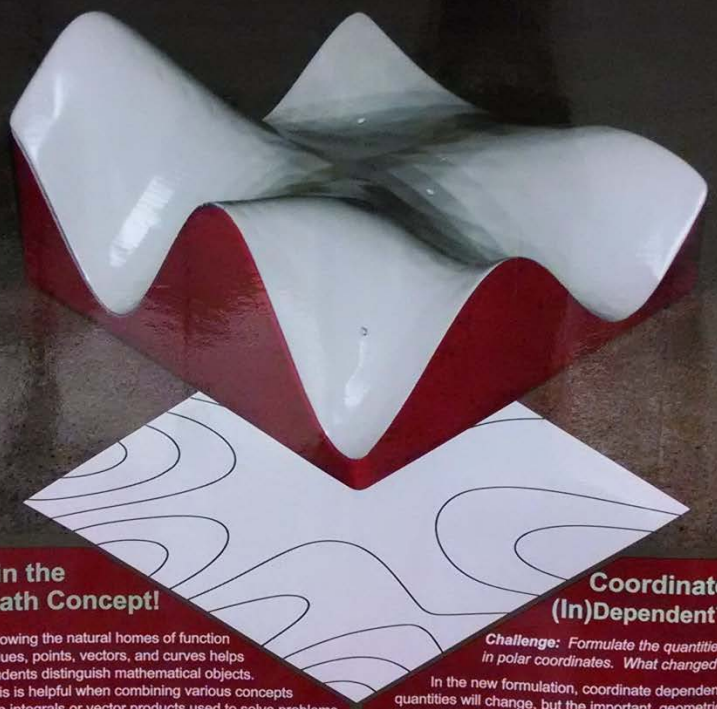
The Tools

Surface - Each surface model is designed to foster group discovery. It has a dry-erase finish to let students draw points, curves, vectors, and regions on it. None of the surfaces contain their algebraic formulas.
Contour Board - A dry-erase contour board providing a two-dimensional representation of each surface.
Inclinometer - A simple tool (pictured above) capable of measuring the slope or linear change in any direction on the surface .

Where are the maximums?

Where is there the most change? (... at a point?)

How can you the center of mass?



Pin the Math Concept!

Knowing the natural homes of function values, points, vectors, and curves helps students distinguish mathematical objects. This is helpful when combining various concepts into integrals or vector products used to solve problems.

Coordinate (In)Dependent?

Challenge: *Formulate the quantities in polar coordinates. What changed?*

In the new formulation, coordinate dependent quantities will change, but the important geometric concepts won't - They are coordinate independent!

mass density ρ curve $\rho = 5\frac{g}{cm^2}$ $d\vec{r}$ $\int_C \vec{\nabla}\rho \cdot d\vec{r}$

point P gradient $\vec{\nabla}\rho$ $d\vec{A} = d\vec{r}_1 \times d\vec{r}_2$ $\int_R \rho \, dA$

Finding Connections between Representations

Challenge: *What happens on the surface when the contour lines are close together?*

The questions above and on the left can be answered using the surface or contour plot - not just with the algebraic formula. We want students to flexibly transition between representations and use them together to synthesize new knowledge. The surfaces help us design activities that foster the exploration of these connections.

Coordinate Systems are a Choice!

Math and science problems aren't defined by coordinate systems. Contrary to students beliefs, measurable quantities like rates of change, locations and amounts exist independent of the coordinate system chosen to describe the problem. Since solutions derived in one system must be equal to solutions obtained from any other coordinate system, students can decide which system is most appropriate for describing their problem.

What is important to you?

We are very interested in how scientists think about these concepts in their field. Sample activities are listed below. Please try them out with the surface and tools.

Intrigued? We'd love to hear feedback!

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Designing an Undergraduate Statistics Program for the Future

Winona State University

April Kerby, Brant Deppa, Tisha Hooks, and Chris Malone

Motivation

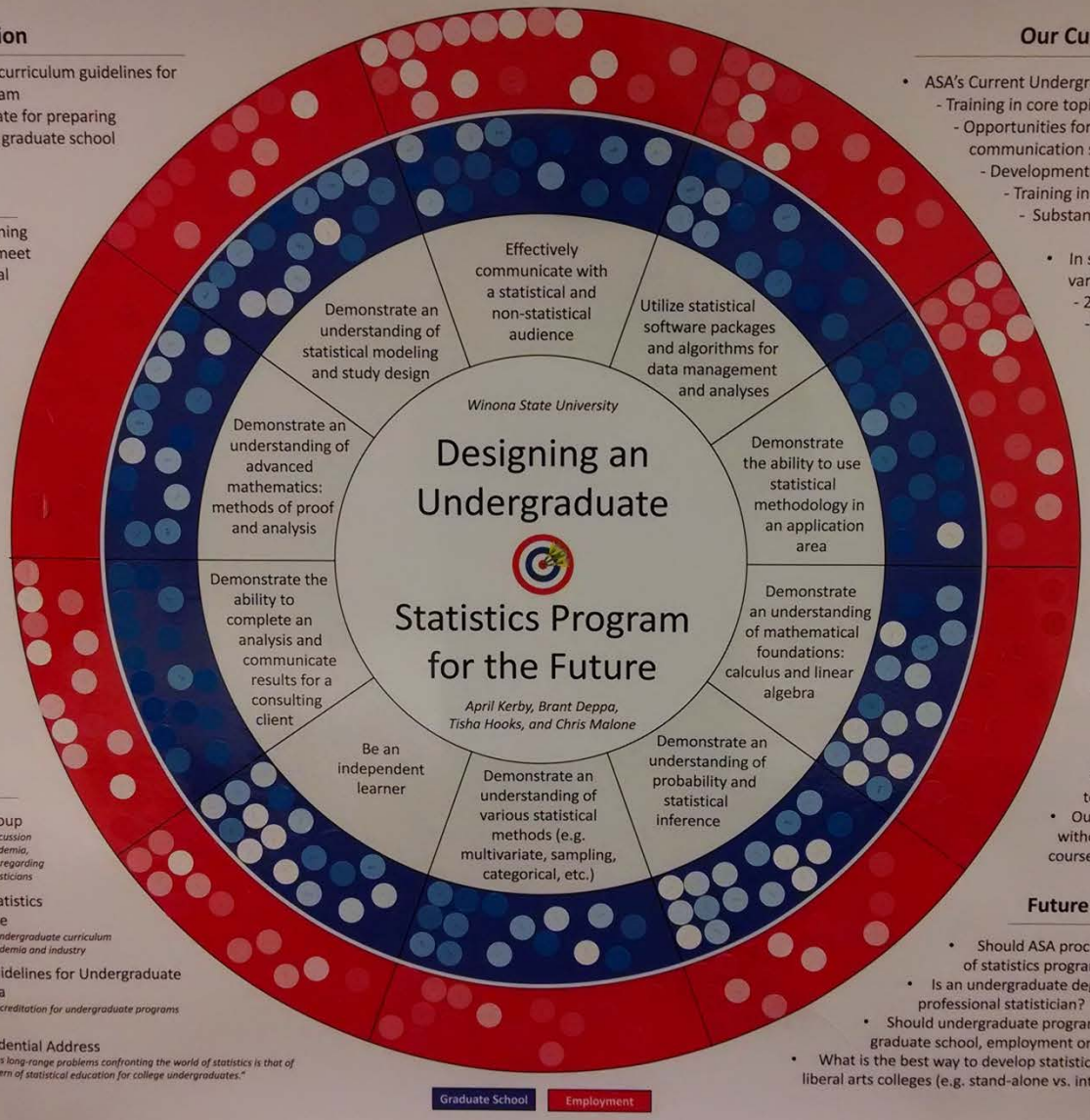
- Continue to develop appropriate curriculum guidelines for an undergraduate statistics program
- Ensure that outcomes are adequate for preparing students for employment and/or graduate school

Past Considerations

- Minton (1983) suggests that training undergraduates is necessary to meet the demands of industry and vital to the growth of our graduate programs.
- Higgins (1999) recognizes the need for training statisticians at the undergraduate level and provides specific suggestions for this curriculum.
- Hogg (1999) urges us to assess and improve the statistics curriculum, especially at the undergraduate level.
- Bryce et al. (2001) discuss the problem with the lack of consensus on the undergraduate curriculum.
- Moore (2001) states, "Our future depends on achieving a more prominent place in undergraduate education beyond the first methods course."

ASA's Progression

- **2010** — Education Workgroup
  Purpose: To facilitate a discussion among statisticians in academia, industry, and government regarding the training of future statisticians
- **1999** — Undergraduate Statistics Education Initiative
  - Organized workshop on undergraduate curriculum
  - Representatives from academia and industry
- **1986** — Committee on Guidelines for Undergraduate Statistics Curricula
  Investigated concept of accreditation for undergraduate programs
- **1950** — Wilks's ASA Presidential Address
  "... one of the most serious long-range problems confronting the world of statistics is that of establishing a sound pattern of statistical education for college undergraduates."



Our Current State

- ASA's Current Undergraduate Curriculum Guidelines
  - Training in core topics
  - Opportunities for collaboration and development of communication skills
  - Development of computational skills
  - Training in mathematical foundations
  - Substantial training in an application area
- In spite of these guidelines, curriculum varies widely at the undergraduate level
  - 22 programs were investigated
  - Programs were selected from schools of varying sizes and across several geographic regions
  - Program requirements:
    - Multivariable calculus: 17/22
    - Proof course: 8/22
    - At least one CS course: 15/22
    - At least one course in an application area: 5/22

Program Outcomes

- Several schools are faced with preparing students for employment and/or graduate school within the same program
- Several outcomes for a program such as this have been identified after reviewing ASA's guidelines and the past work of others. These are listed to the left.
- Outcomes were identified without specifically mentioning courses to allow for flexibility.

Future Considerations

- Should ASA proceed with accreditation of statistics programs to improve consistency?
- Is an undergraduate degree sufficient to be a professional statistician?
- Should undergraduate programs train statisticians for graduate school, employment or both?
- What is the best way to develop statistics programs at small liberal arts colleges (e.g. stand-alone vs. interdisciplinary) ?

The Data Scientist Degree – A Necessity for Growth in our Discipline

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Big Data on the Rise

- "By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions." (McKinsey Global Institute Report)
- The Bureau of Labor Statistics projects a 14% increase in statistics jobs between 2010 and 2020. The authors feel that this figure is low because it probably does not include the broader definition of data scientist.

Where is Statistics?

A commonly accepted definition of statistics is the science of data. Our discipline should be an integral part of training students to meet the demands for the data scientist.

The College of Charleston, who offered the first undergraduate data science degree in the U.S., states "…the program teaches [students] how to use the tools and problem solving skills of mathematics and computer science as a way to obtain information from large, multidimensional datasets…" (Notice statistics is not mentioned.)

Data Science 101 lists 114 data science programs. A review of the list found:

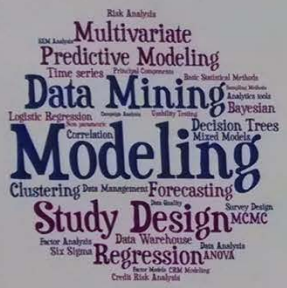
- Only 6 provide training at the undergraduate level, none of which are rooted in statistics.
- Only 5 have "statistics" in their program name, none of which are in the U.S.

Marie Davidian stated in a recent *AMSTAT NEWS* article, "We likewise must take steps to enhance our profession's role in Big Data practice… We also must be prepared to understand other ways of thinking that are critical in the Age of Big Data and to integrate these with our own expertise and knowledge."

A Survey of the Necessary Skills for Employment

A thorough review of "Analytics" job postings on monster.com and icrunchdata.com was completed to identify the necessary skill-set for employment as a data scientist. A total of 131job postings were summarized and the specified skills were categorized into the following themes.

Content Knowledge



The curriculum should provide…

- a solid foundation in modeling techniques.
- a thorough understanding of study design.
- training in data mining and predictive analytics.
- exposure to working with big data.

Computing Skills

- The use of statistical software should be used throughout the curriculum.
- Students need experience working with database management tools.
- Students must have experience with a programming language.
- Students need to be well versed in performing tasks using non-statistical software (e.g. pivot tables in Excel).

Professional Skills

- Students must have experience writing reports geared towards a non-technical audience on numerous assignments across the curriculum.
- Students should present results/findings to peers on several occasions to enhance their communication skills.
- The curriculum should provide an appropriate balance between team/group and independent learning.
- The curriculum must provide ample opportunities to enhance problem solving and analytical skills.

Where We Are

Many programs for training data scientists have been created in recent years and few, if any, are affiliated with statistics departments. Statistical thinking is a major component of the necessary skill-set of a data scientist; therefore, it is critical for our discipline to embrace and contribute to such programs. At JSM 2012 the authors presented preliminary work on "The Undergraduate Statistics Program of the Future" which highlighted the fact that the current undergraduate statistics curriculum may not properly prepare students seeking employment as a data scientist. The authors have developed a Data Scientist Degree which is a compilation of statistics and computer science courses, courses in an application area, and a substantial independent learning component. Our discipline should embrace this type of degree in order to meet the demands of future employers.

Moving Forward

To create the data scientist degree that will best serve our students we need to recognize that…

- **The traditional statistics curriculum does not meet the needs of industry.**
- **The curriculum must be modernized to embrace computing.**
- **The curriculum must remain closely tied to the demands of industry.**
- **Students need to gain discipline specific knowledge (e.g. health care, business, etc.)**

References

AMSTAT NEWS. "The ASA and Big Data." June 2013. http://magazine.amstat.org/blog/2013/06/01/the-asa-and-big-data/

Bureau of Labor Statistics. http://www.bls.gov/emp/ep_table_102.htm

Data Science 101. http://datascience101.wordpress.com/2012/04/09/colleges-with-data-science-degrees/

McKinsey Global Institute. "Big data: The next frontier for innovation, competition, and productivity." May 2011. http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation.

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