THE COLLEGE OF NEW JERSEY

Mathematics and Statistics

2014

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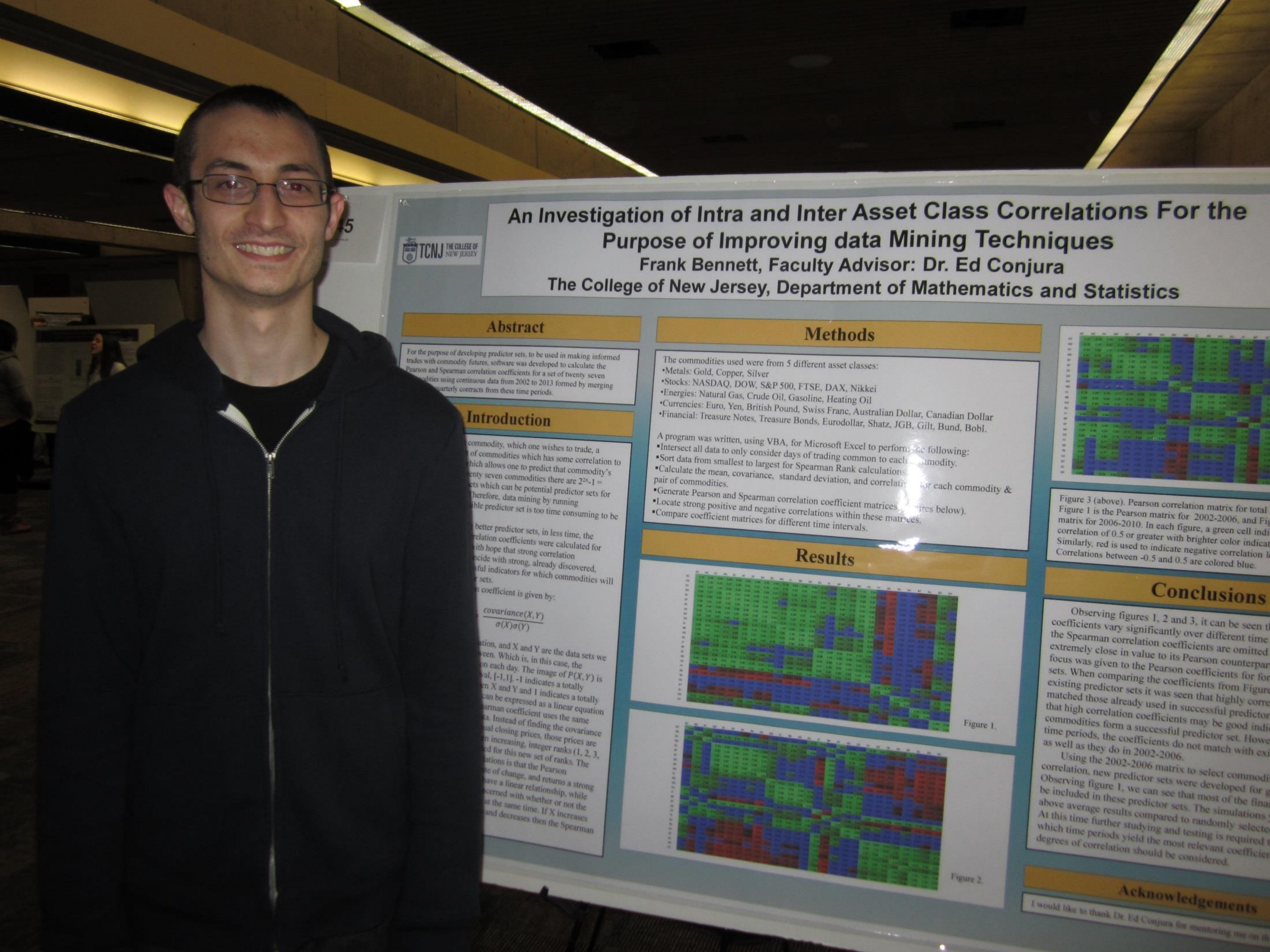
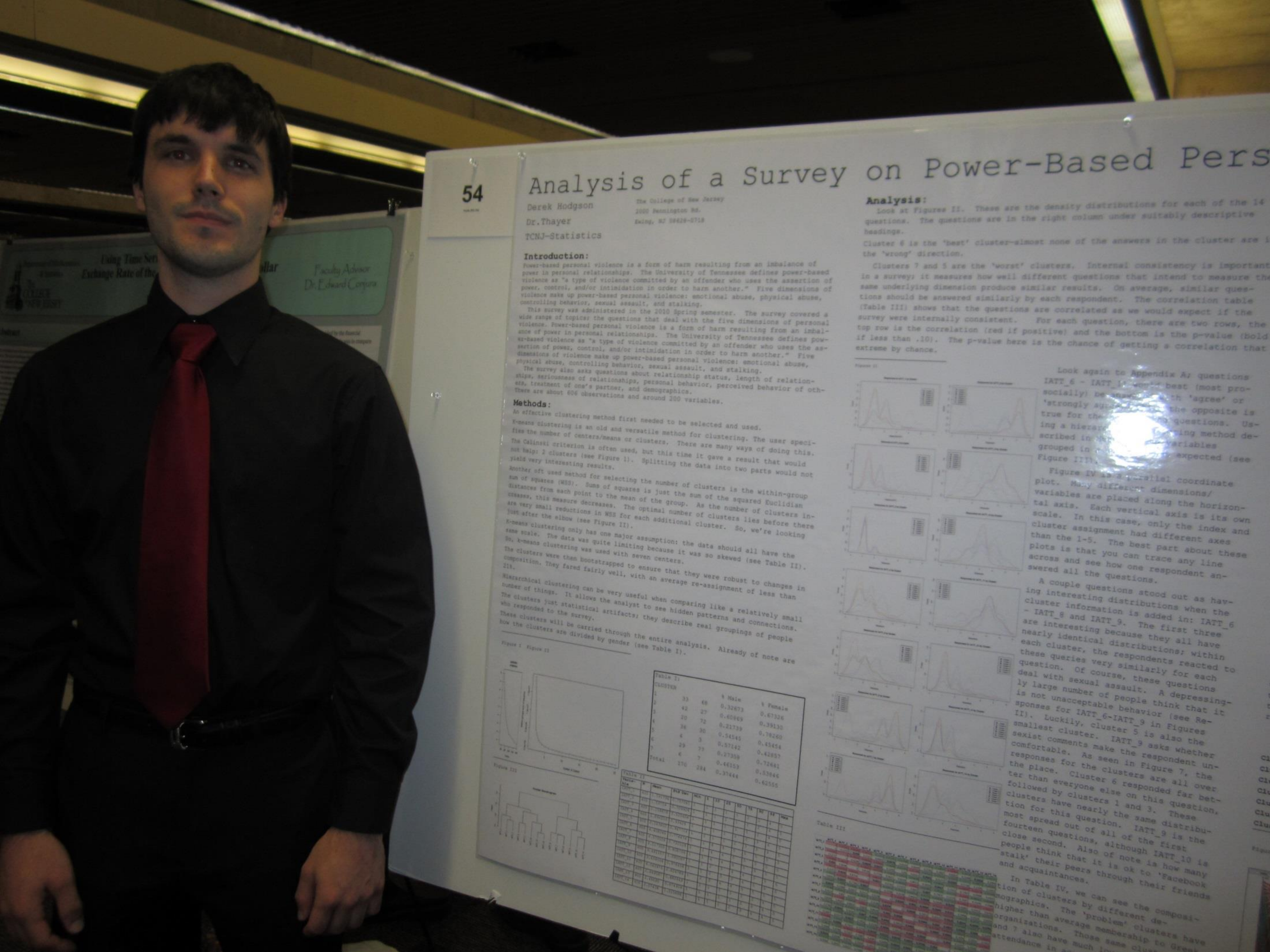

An Investigation of Intra and Inter Asset Class Correlations For the Purpose of Improving data Mining Techniques
Frank Bennett, Faculty Advisor: Dr. Ed Conjura
The College of New Jersey, Department of Mathematics and Statistics
TCNJ THE COLLEGE OF NEW JERSEY
Abstract
For the purpose of developing predictor sets, to be used in making informed trades with commodity futures, software was developed to calculate the Pearson and Spearman correlation coefficients for a set of twenty seven
Introduction
Methods
The commodities used were from 5 different asset classes:
•Metals: Gold, Copper, Silver
•Stocks: NASDAQ, DOW, S&P 500, FTSE, DAX, Nikkei
•Energies: Natural Gas, Crude Oil, Gasoline, Heating Oil
•Currencies: Euro, Yen, British Pound, Swiss Franc, Australian Dollar, Canadian Dollar
•Financial: Treasure Notes, Treasure Bonds, Eurodollar, Shatz, JGB, Gilt, Bund, Bobl.
•Compare coefficient matrices for different time intervals.
Results
Figure 1.
Figure 2.
Conclusions
Acknowledgements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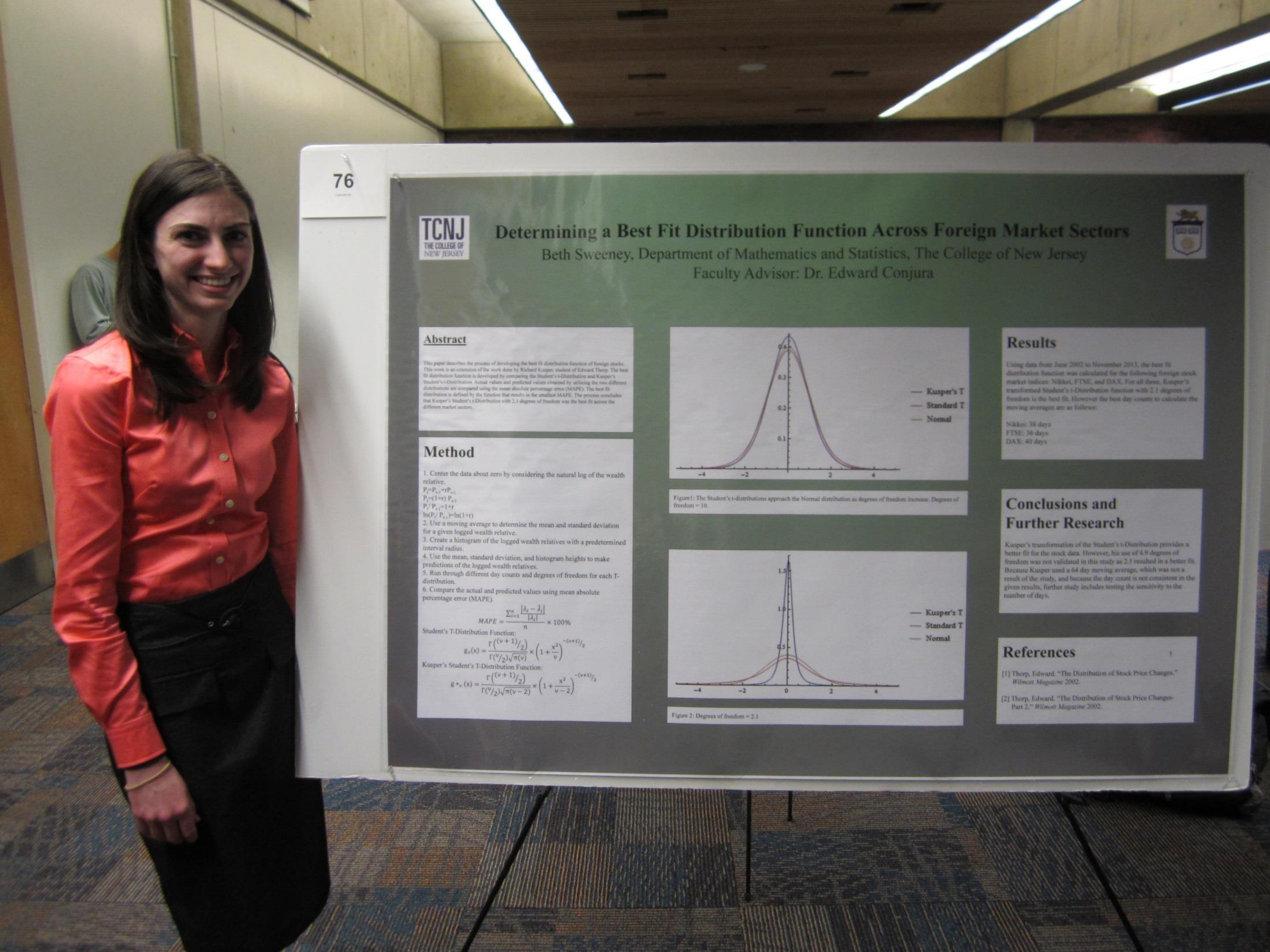
Analysis of a Survey on Power-Based Pers
Derek Hodgson
Dr.Thayer
TCNJ-Statistics
Introduction:
Methods:
Analysis:
Faculty Advisor
Dr. Edward Conjura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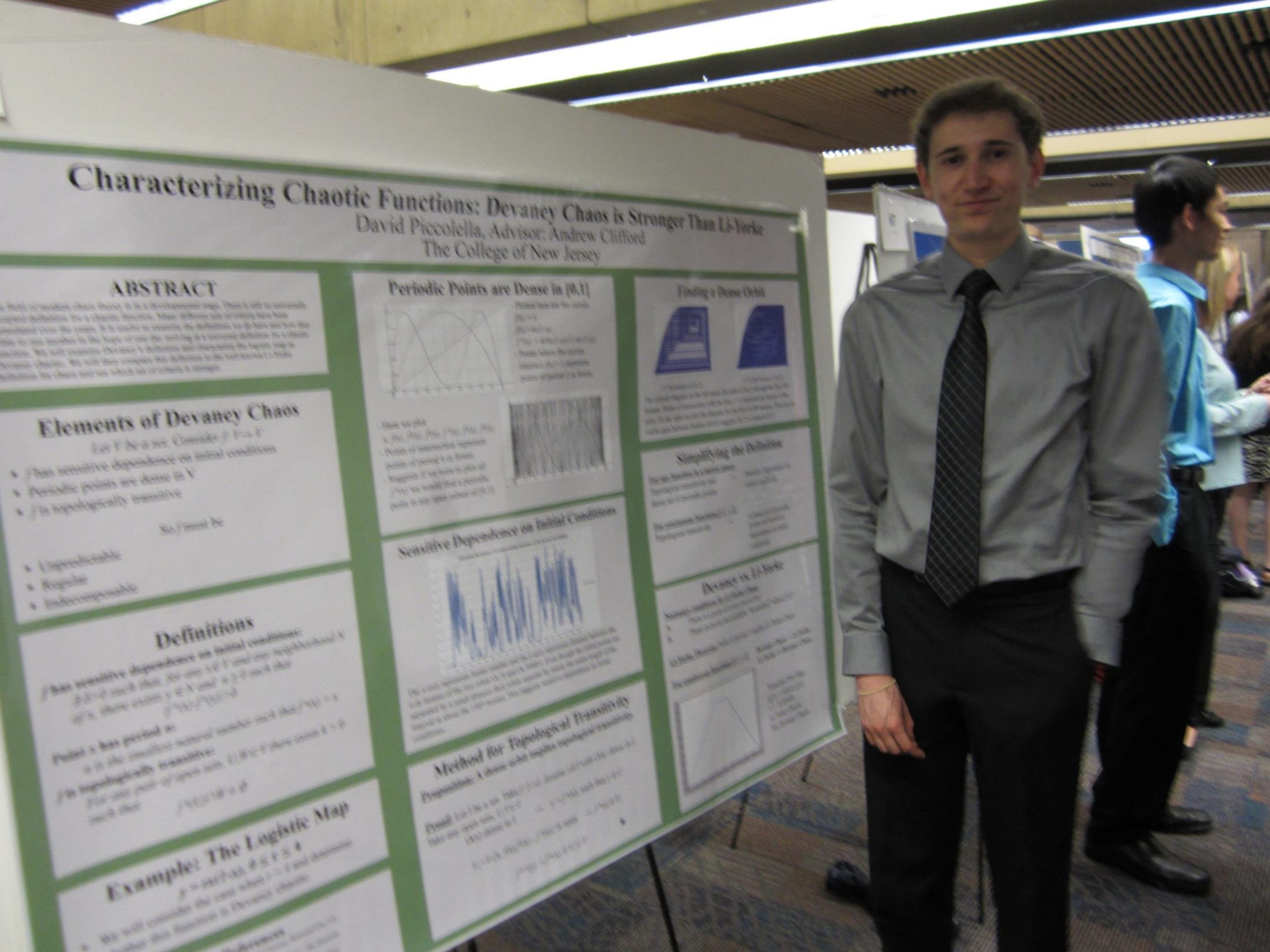
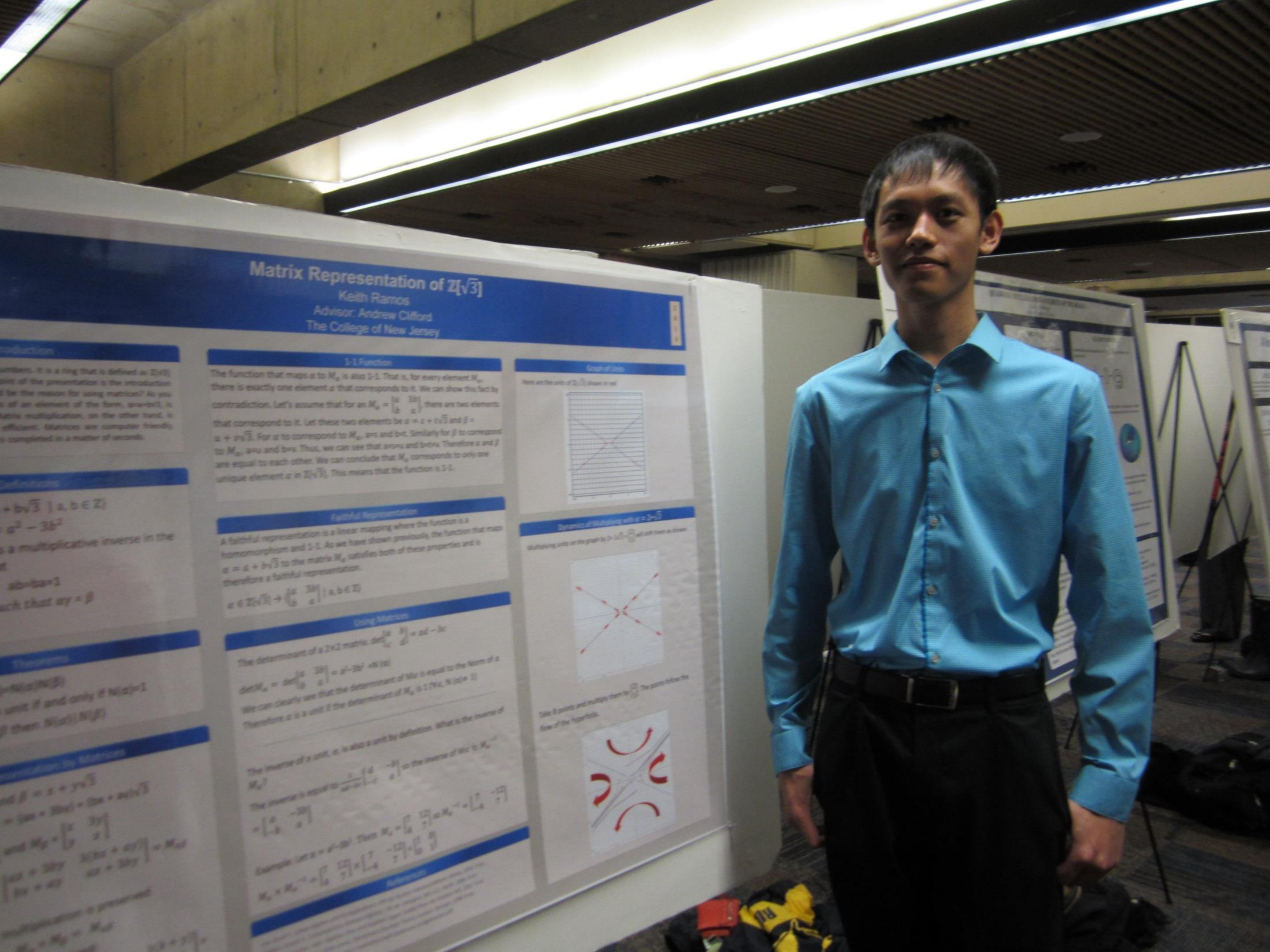
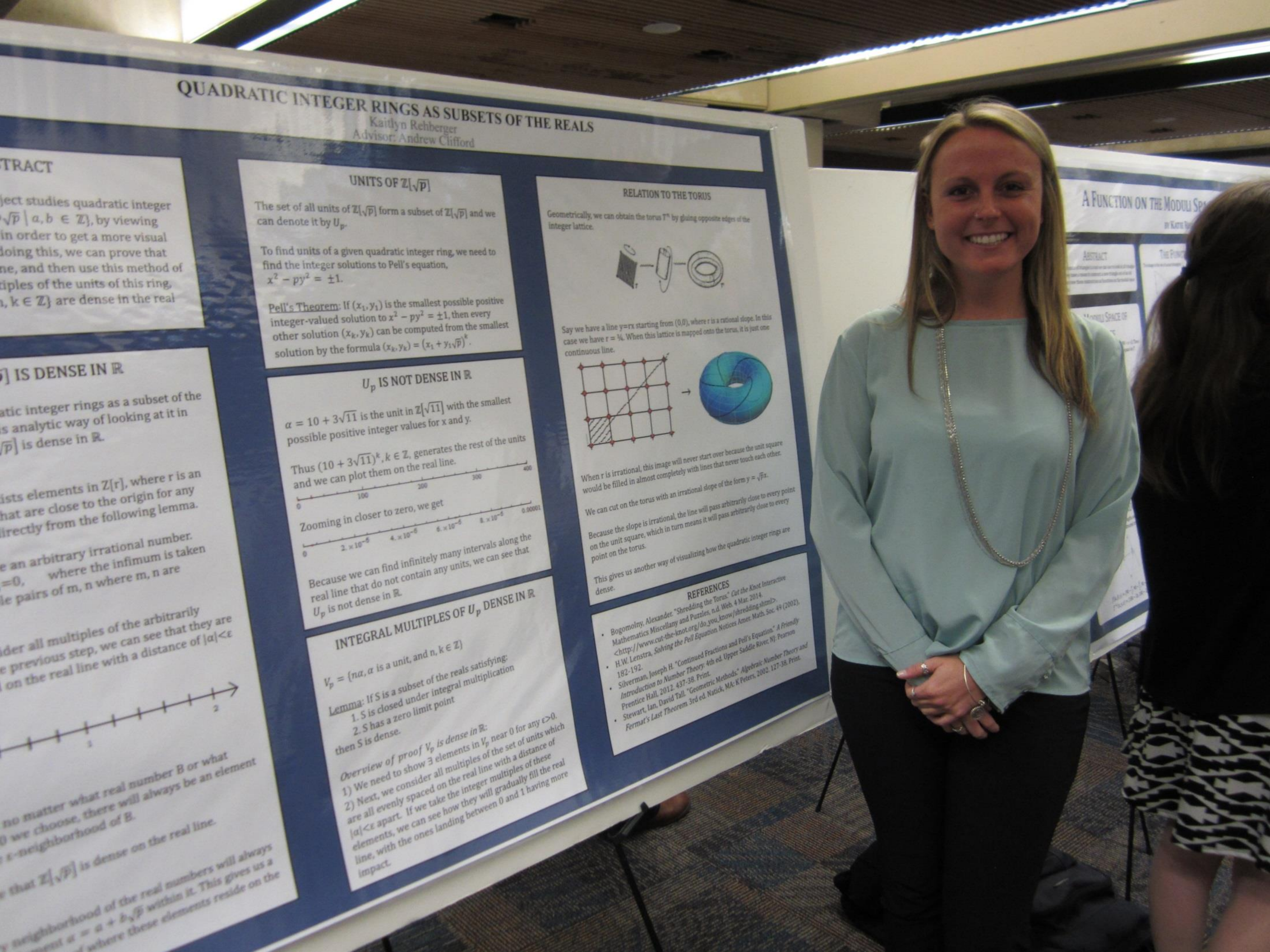
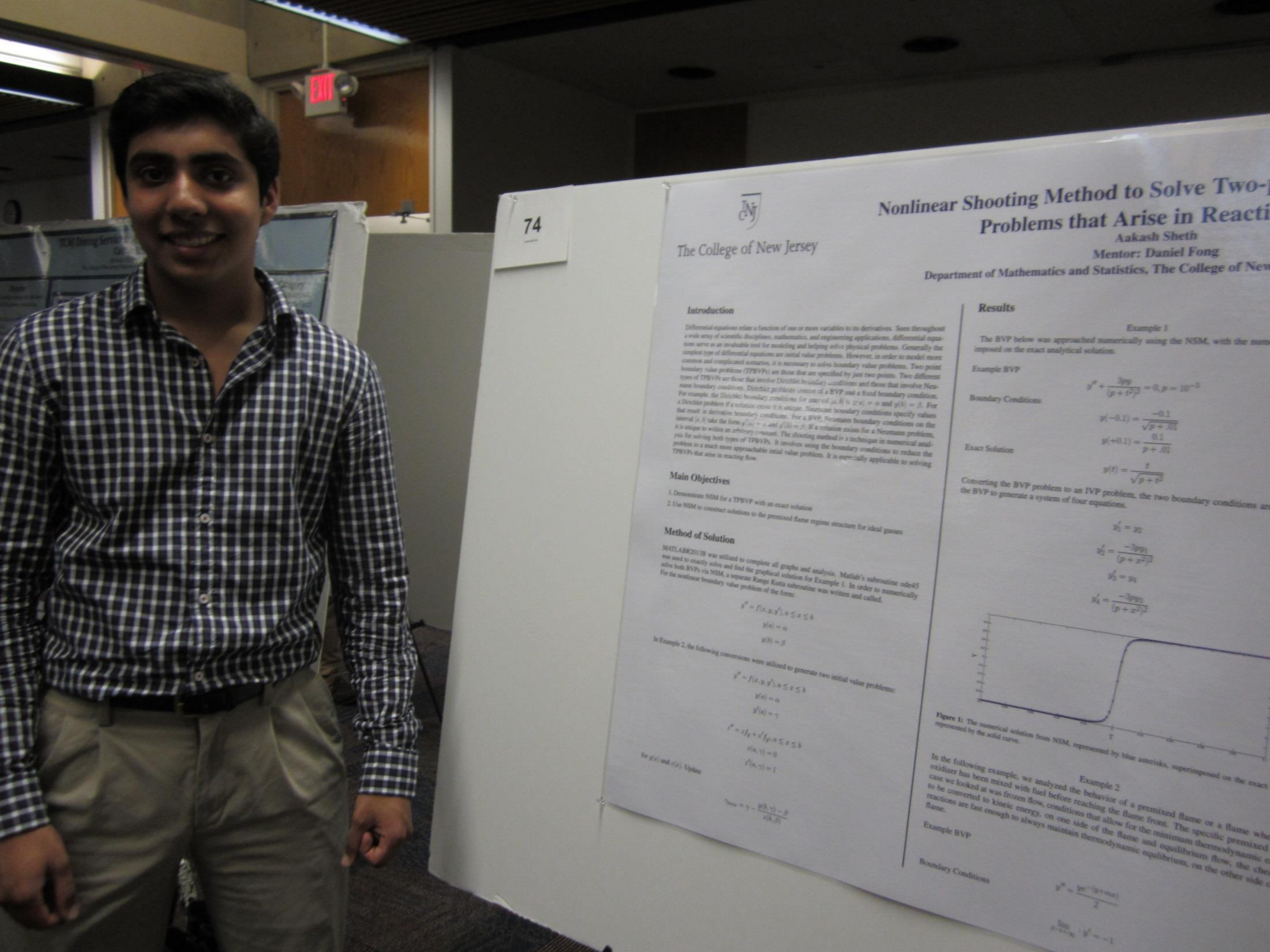
Determining a Best Fit Distribution Function Across Foreign Market Sectors
Beth Sweeney, Department of Mathematics and Statistics, The College of New Jersey
Faculty Advisor: Dr. Edward Conjura
Abstract
This paper describes the process of developing the best fit distribution function of foreign stocks. This work is an extension of the work done by Richard Kusper, student of Edward Thorp. The best fit distribution function is developed by comparing the Student's t-Distribution and Kusper's Student's t-Distribution. Actual values and predicted values obtained by utilizing the two different distributions are compared using the mean absolute percentage error (MAPE). The best fit distribution is defined by the function that results in the smallest MAPE. The process concludes that Kusper's Student's t-Distribution with 2.1 degrees of freedom was the best fit across the different market sectors.
Method
1. Center the data about zero by considering the natural log of the wealth relative.
2. Use a moving average to determine the mean and standard deviation for a given logged wealth relative.
3. Create a histogram of the logged wealth relatives with a predetermined interval radius.
4. Use the mean, standard deviation, and histogram heights to make predictions of the logged wealth relatives.
5. Run through different day counts and degrees of freedom for each T-distribution.
6. Compare the actual and predicted values using mean absolute percentage error (MAPE).
Student's T-Distribution Function:
Kusper's Student's T-Distribution Function:
Kusper's T
Standard T
Normal
Figure1: The Student's t-distributions approach the Normal distribution as degrees of freedom increase. Degrees of freedom = 10.
Kusper's T
Standard T
Normal
Figure 2: Degrees of freedom = 2.1
Results
Using data from June 2002 to November 2013, the best fit distribution function was calculated for the following foreign stock market indices: Nikkei, FTSE, and DAX. For all three, Kusper's transformed Student's t-Distribution function with 2.1 degrees of freedom is the best fit. However the best day counts to calculate the moving averages are as follows:
Nikkei: 38 days
FTSE: 36 days
DAX: 40 days
Conclusions and Further Research
Kusper's transformation of the Student's t-Distribution provides a better fit for the stock data. However, his use of 4.9 degrees of freedom was not validated in this study as 2.1 resulted in a better fit. Because Kusper used a 64 day moving average, which was not a result of the study, and because the day count is not consistent in the given results, further study includes testing the sensitivity to the number of days.
References
[1] Thorp, Edward. "The Distribution of Stock Price Changes." Wilmott Magazine 2002.
[2] Thorp, Edward. "The Distribution of Stock Price Changes-Part 2." Wilmott Magazine 2002.


Characterizing Chaotic Functions: Devaney Chaos is Stronger Than Li-Yorke
David Piccolella, Advisor: Andrew Clifford
The College of New Jersey
ABSTRACT
Periodic Points are Dense in [0,1]
Finding a Dense Orbit
Elements of Devaney Chaos
f has sensitive dependence on initial conditions
Periodic points are dense in V
f is topologically transitive
So f must be
Unpredictable
Regular
Indecomposable
Simplifying the Definition
Sensitive Dependence on Initial Conditions
Devaney vs. Li-Yorke
Definitions
Method for Topological Transitivity
Example: The Logistic Map


Matrix Representation of ℤ[√3]
Keith Ramos
Advisor: Andrew Clifford
The College of New Jersey
1-1 Function
Graph of Units
Faithful Representation
Using Matrices


QUADRATIC INTEGER RINGS AS SUBSETS OF THE REALS
Kaitlyn Rehberger
Advisor: Andrew Clifford
UNITS OF ℤ[√p]
The set of all units of ℤ[√p] form a subset of ℤ[√p] and we can denote it by U_p.
To find units of a given quadratic integer ring, we need to find the integer solutions to Pell's equation, $x^2 - py^2 = \pm 1$.
Pell's Theorem: If (x_1, y_1) is the smallest possible positive integer-valued solution to $x^2 - py^2 = \pm 1$, then every other solution (x_k, y_k) can be computed from the smallest solution by the formula $(x_k, y_k) = (x_1 + y_1\sqrt{p})^k$.
U_p IS NOT DENSE IN ℝ
$\alpha = 10 + 3\sqrt{11}$ is the unit in ℤ[√11] with the smallest possible positive integer values for x and y.
Thus $(10 + 3\sqrt{11})^k, k \in ℤ$, generates the rest of the units and we can plot them on the real line.
Zooming in closer to zero, we get
Because we can find infinitely many intervals along the real line that do not contain any units, we can see that U_p is not dense in ℝ.
INTEGRAL MULTIPLES OF U_p DENSE IN ℝ
INTEGRAL MULTIPLES OF U_p DENSE IN ℝ
V_p = {nα, α is a unit, and n, k ∈ ℤ}
Lemma: If S is a subset of the reals satisfying:
1. S is closed under integral multiplication
2. S has a zero limit point
then S is dense.
RELATION TO THE TORUS
Geometrically, we can obtain the torus by gluing opposite edges of the integer lattice.
When r is irrational, this image will never start over because the unit square would be filled in almost completely with lines that never touch each other.
This gives us another way of visualizing how the quadratic integer rings are dense.
REFERENCES
A FUNCTION ON THE MODULI SPACE


EXIT
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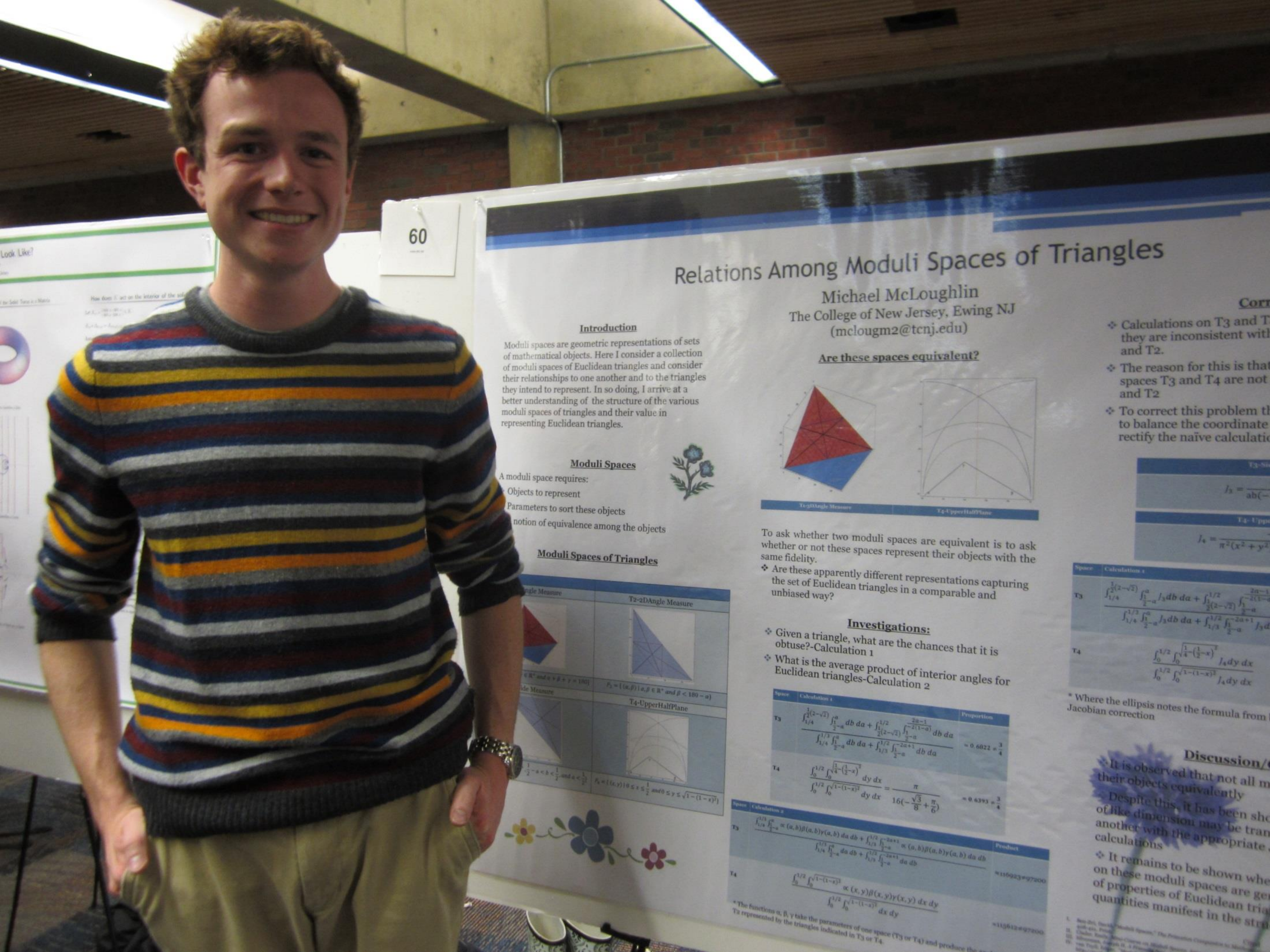
The College of New Jersey
Nonlinear Shooting Method to Solve Two-
Problems that Arise in Reacti
Aakash Sheth
Mentor: Daniel Fong
Department of Mathematics and Statistics, The College of New
Introduction
Main Objectives
1. Demonstrate NSM for a TPBVP with an exact solution
2. Use NSM to construct solutions to the premixed flame regime structure for ideal gasses
Method of Solution
Results
Example 1
The BVP below was approached numerically using the NSM, with the nume
imposed on the exact analytical solution.
Example BVP
Boundary Conditions
Exact Solution
Converting the BVP problem to an IVP problem, the two boundary conditions ar
the BVP to generate a system of four equations.
Figure 1: The numerical solution from NSM, represented by blue asterisks, superimposed on the exact
represented by the solid curve.
Example 2
In the following example, we analyzed the behavior of a premixed flame or a flame wh
Example BVP
Boundary Conditions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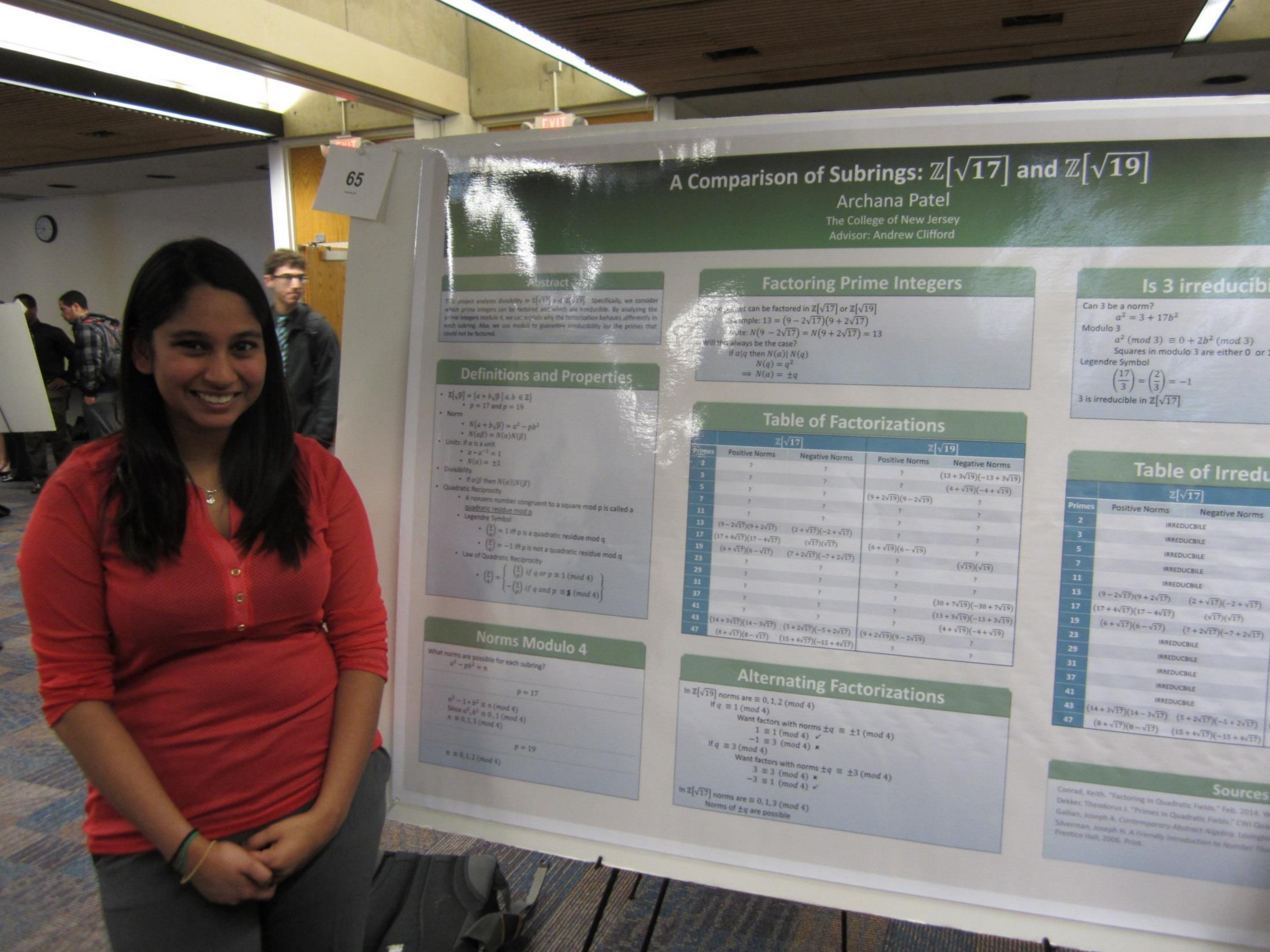
Relations Among Moduli Spaces of Triangles
Michael McLoughlin
The College of New Jersey, Ewing NJ
(mclougm2@tcnj.edu)
Introduction
Moduli spaces are geometric representations of sets of mathematical objects. Here I consider a collection of moduli spaces of Euclidean triangles and consider their relationships to one another and to the triangles they intend to represent. In so doing, I arrive at a better understanding of the structure of the various moduli spaces of triangles and their value in representing Euclidean triangles.
Moduli Spaces
A moduli space requires:
Objects to represent
Parameters to sort these objects
notion of equivalence among the objects
Moduli Spaces of Triangles
T2-2DAngle Measure
T4-UpperHalfPlane
Are these spaces equivalent?
To ask whether two moduli spaces are equivalent is to ask whether or not these spaces represent their objects with the same fidelity.
Are these apparently different representations capturing the set of Euclidean triangles in a comparable and unbiased way?
Investigations:
Given a triangle, what are the chances that it is obtuse?-Calculation 1
What is the average product of interior angles for Euclidean triangles-Calculation 2
Calculations on T3 and T
they are inconsistent wit
and T2.
The reason for this is tha
spaces T3 and T4 are not
and T2
To correct this problem th
to balance the coordinate
rectify the naïve calculati
* Where the ellipsis notes the formula from
Jacobian correction
Discussion/
It is observed that not all m
their objects equivalently
Despite this, it has been sho
of like dimension may be tran
another with the appropriate
calculations
It remains to be shown whe
on these moduli spaces are ge
of properties of Euclidean tria
quantities manifest in the str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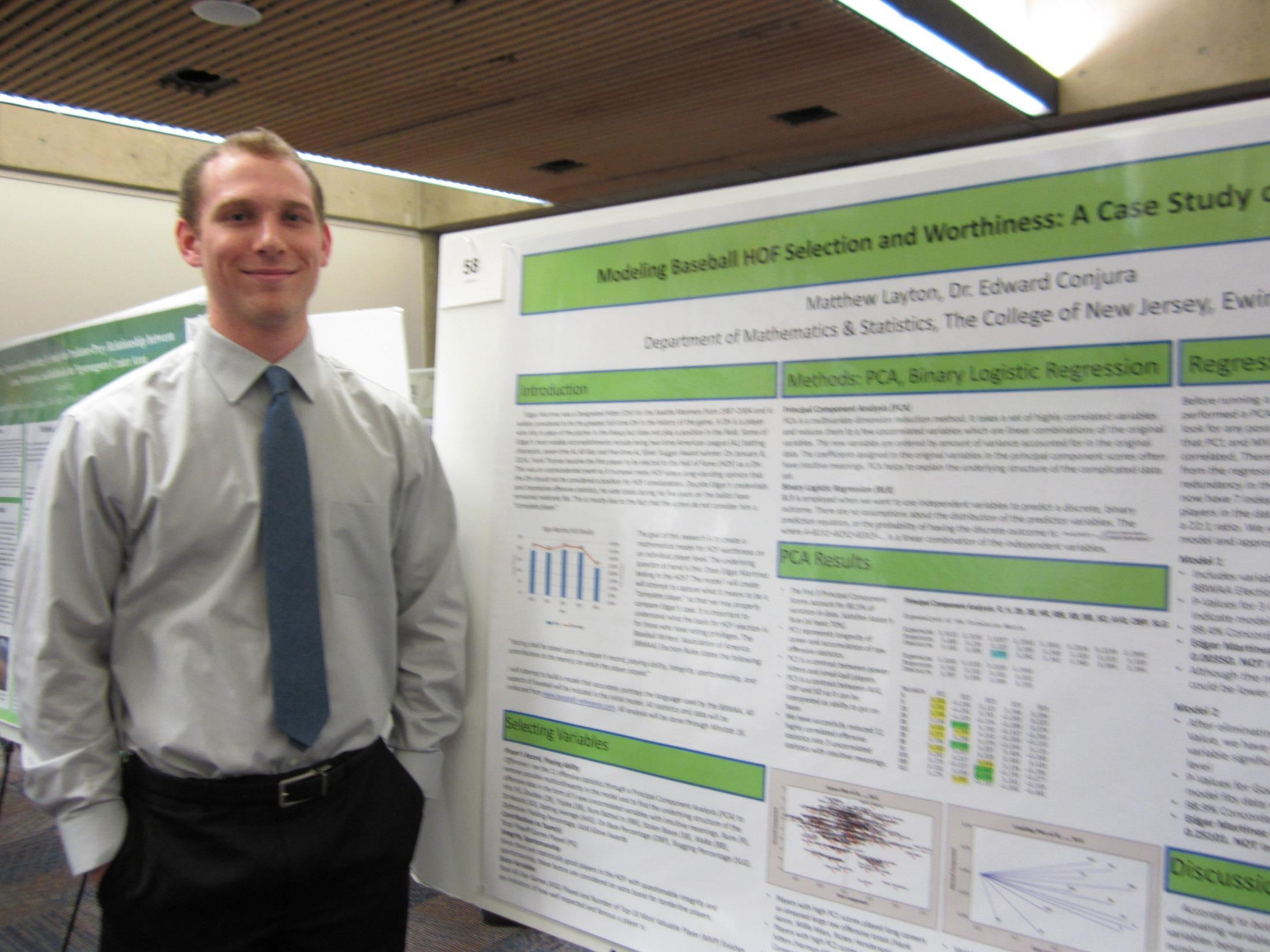
A Comparison of Subrings: $\mathbb{Z}[\sqrt{17}]$ and $\mathbb{Z}[\sqrt{19}]$
Archana Patel
The College of New Jersey
Advisor: Andrew Clifford
Abstract
Definitions and Properties
Norms Modulo 4
Factoring Prime Integers
can be factored in $\mathbb{Z}[\sqrt{17}]$ or $\mathbb{Z}[\sqrt{19}]$
$13 = (9 - 2\sqrt{17})(9 + 2\sqrt{17})$
$N(9 - 2\sqrt{17}) = N(9 + 2\sqrt{17}) = 13$
always be the case?
If $\alpha | q$ then $N(\alpha) | N(q)$
$N(q) = q^2$
$\Rightarrow N(\alpha) = \pm q$
Table of Factorizations
Alternating Factorizations
Is 3 irreducib
Can 3 be a norm?
$a^2 = 3 + 17b^2$
Modulo 3
$a^2 \ (mod\ 3) \equiv 0 + 2b^2 \ (mod\ 3)$
Squares in modulo 3 are either 0 or
Legendre Symbol
$\left(\frac{17}{3}\right) = \left(\frac{2}{3}\right) = -1$
3 is irreducible in $\mathbb{Z}[\sqrt{17}]$
Table of Irredu
Sources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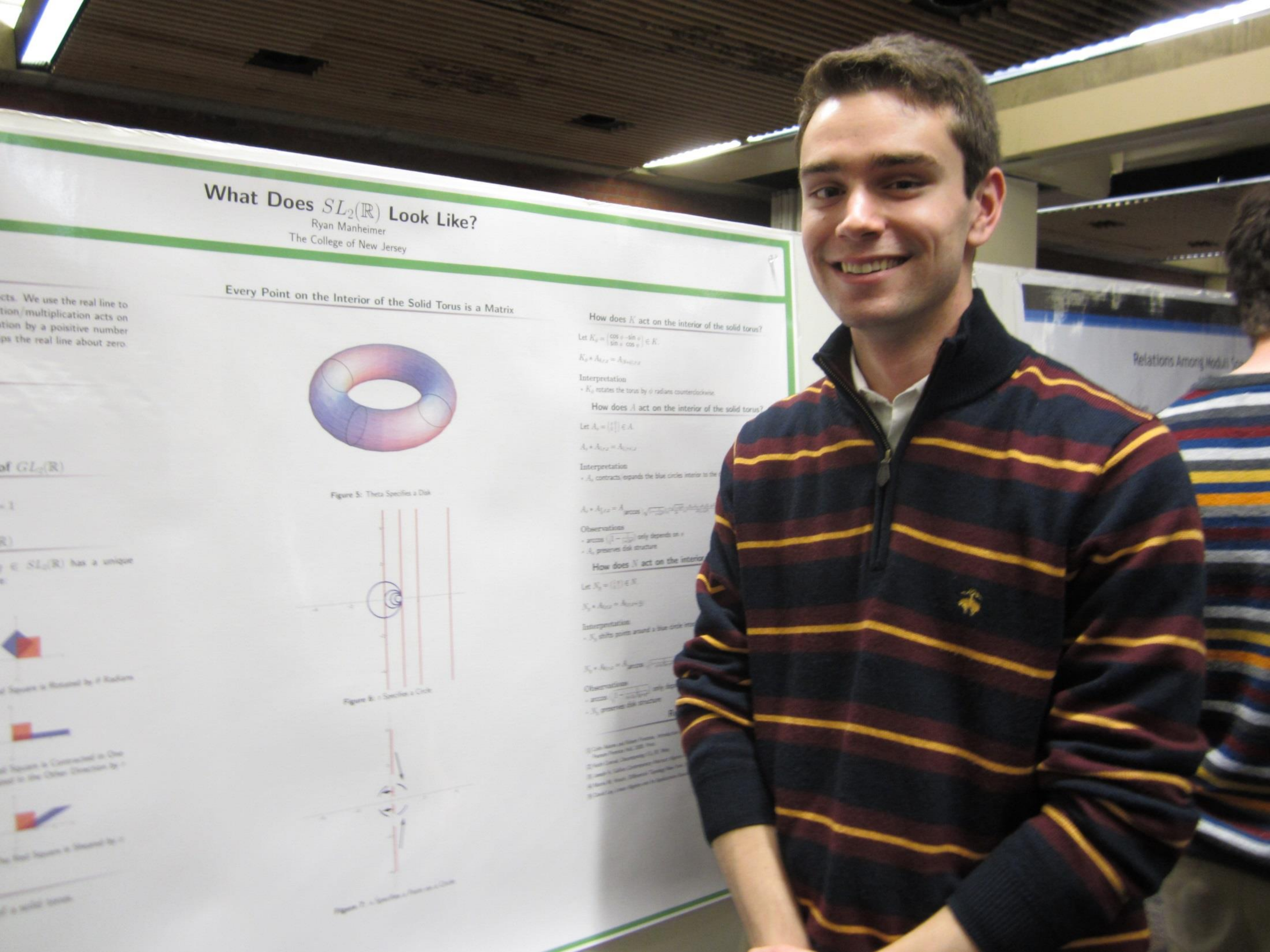
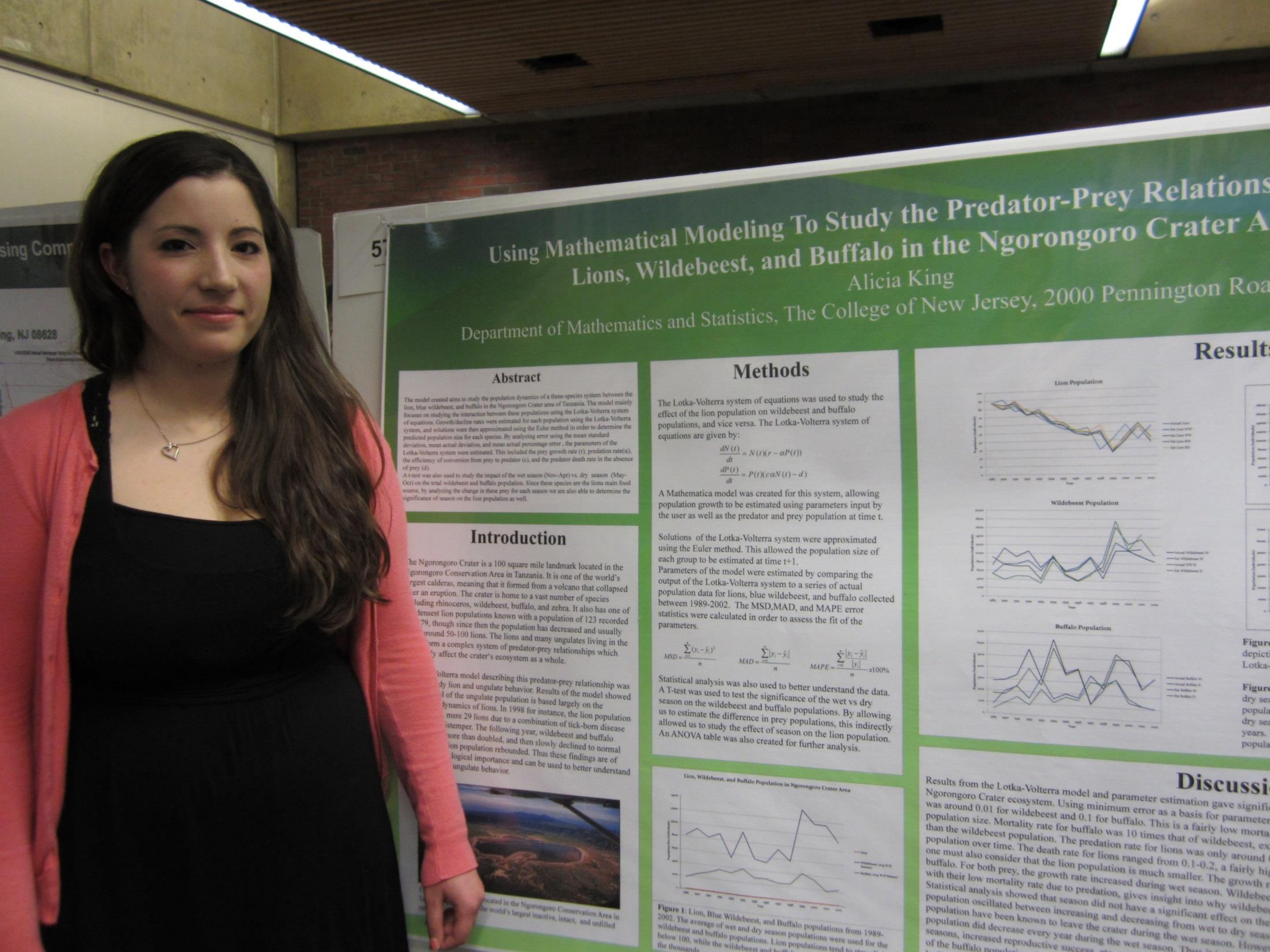
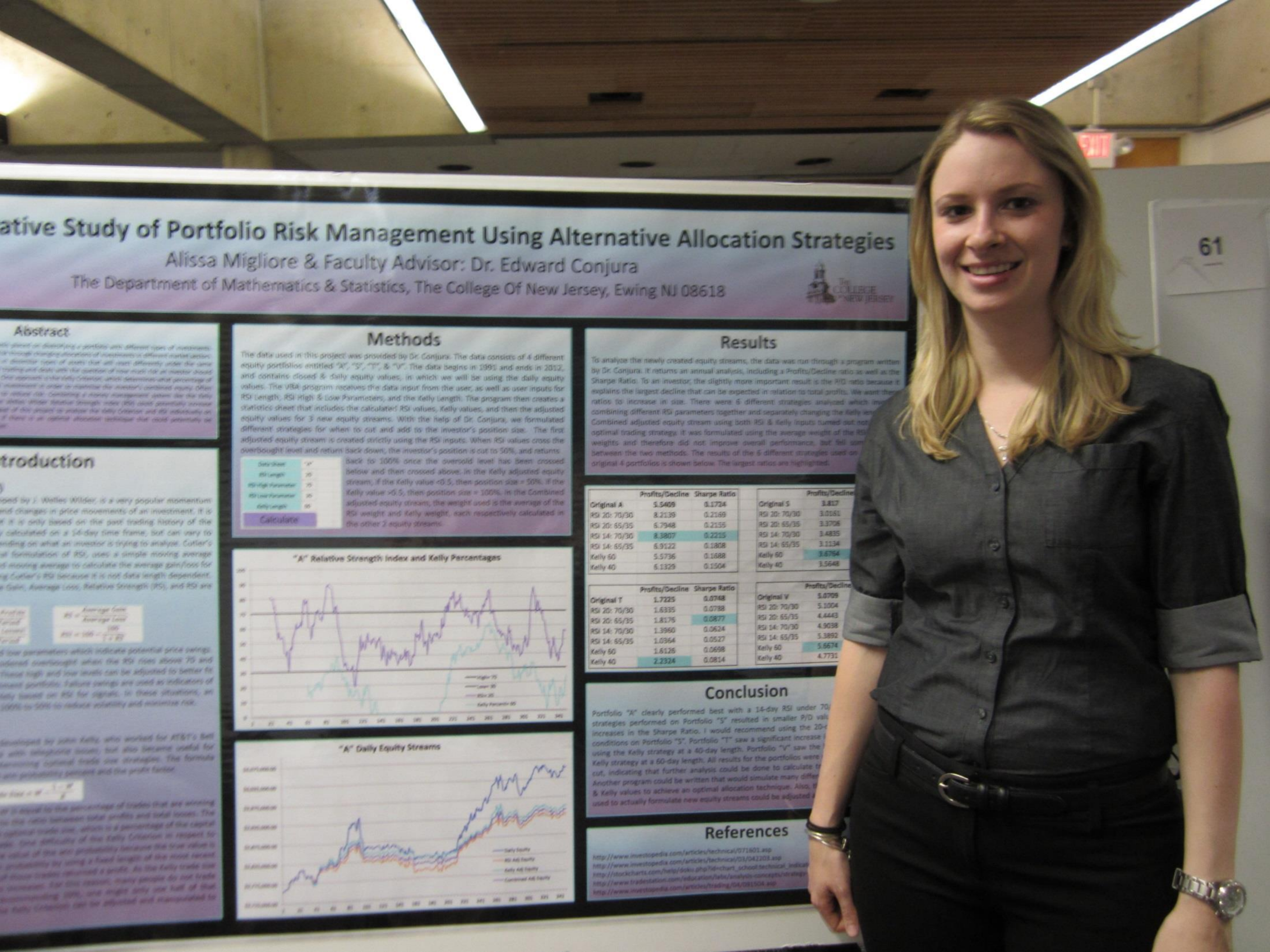
Modeling Baseball HOF Selection and Worthiness: A Case Study o
Matthew Layton, Dr. Edward Conjura
Department of Mathematics & Statistics, The College of New Jersey, Ewin
Introduction
Methods: PCA, Binary Logistic Regression
Regress
PCA Results
Selecting Variables
Discussio


What Does $SL_2(\mathbb{R})$ Look Like?
Ryan Manheimer
The College of New Jersey
Every Point on the Interior of the Solid Torus is a Matrix
How does K act on the interior of the solid torus?
Interpretation
How does A act on the interior of the solid torus?
Interpretation
Observations
Figure 5: Theta Specifies a Disk


Using Mathematical Modeling To Study the Predator-Prey Relations
Lions, Wildebeest, and Buffalo in the Ngorongoro Crater A
Alicia King
Department of Mathematics and Statistics, The College of New Jersey, 2000 Pennington Roa
Abstract
The model created aims to study the population dynamics of a three-species system between the lion, blue wildebeest, and buffalo in the Ngorongoro Crater area of Tanzania. The model mainly focuses on studying the interaction between these populations using the Lotka-Volterra system of equations. Growth/decline rates were estimated for each population using the Lotka-Volterra system, and solutions were then approximated using the Euler method in order to determine the predicted population size for each species. By analyzing error using the mean standard deviation, mean actual deviation, and mean actual percentage error, the parameters of the Lotka-Volterra system were estimated. This included the prey growth rate (r), predation rate(α), the efficiency of conversion from prey to predator (c), and the predator death rate in the absence of prey (d).
A t-test was also used to study the impact of the wet season (Nov-Apr) vs. dry season (May-Oct) on the total wildebeest and buffalo population. Since these species are the lions main food source, by analyzing the change in these prey for each season we are also able to determine the significance of season on the lion population as well.
Introduction
Methods
The Lotka-Volterra system of equations was used to study the effect of the lion population on wildebeest and buffalo populations, and vice versa. The Lotka-Volterra system of equations are given by:
dN(t)/dt = N(t)(r − αP(t))
dP(t)/dt = P(t)(cαN(t) − d)
A Mathematica model was created for this system, allowing population growth to be estimated using parameters input by the user as well as the predator and prey population at time t.
Solutions of the Lotka-Volterra system were approximated using the Euler method. This allowed the population size of each group to be estimated at time t+1.
Parameters of the model were estimated by comparing the output of the Lotka-Volterra system to a series of actual population data for lions, blue wildebeest, and buffalo collected between 1989-2002. The MSD,MAD, and MAPE error statistics were calculated in order to assess the fit of the parameters.
Statistical analysis was also used to better understand the data. A T-test was used to test the significance of the wet vs dry season on the wildebeest and buffalo populations. By allowing us to estimate the difference in prey populations, this indirectly allowed us to study the effect of season on the lion population. An ANOVA table was also created for further analysis.
Lion, Wildebeest, and Buffalo Population in Ngorongoro Crater Area
Figure 1: Lion, Blue Wildebeest, and Buffalo populations from 1989-2002. The average of wet and dry season populations were used for the wildebeest and buffalo populations.
Results
Lion Population
Wildebeest Population
Buffalo Population
Discussi
Results from the Lotka-Volterra model and parameter estimation gave signifi
was around 0.01 for wildebeest and 0.1 for buffalo. This is a fairly low morta
population size. Mortality rate for buffalo was 10 times that of wildebeest, ex
than the wildebeest population. The predation rate for lions was only around
population over time. The death rate for lions ranged from 0.1-0.2, a fairly hi
one must also consider that the lion population is much smaller. The growth
buffalo. For both prey, the growth rate increased during wet season. Wildebe
with their low mortality rate due to predation, gives insight into why wildebe
Statistical analysis showed that season did not have a significant effect on th
population oscillated between increasing and decreasing from wet to dry sea
population have been known to leave the crater during the wet season. Howe
population did decrease every year during the wet season.


ative Study of Portfolio Risk Management Using Alternative Allocation Strategies
Alissa Migliore & Faculty Advisor: Dr. Edward Conjura
The Department of Mathematics & Statistics, The College Of New Jersey, Ewing NJ 08618
Abstract
Methods
Results
troduction
"A" Relative Strength Index and Kelly Percentages
"A" Daily Equity Streams
Calculate
Conclusion
References
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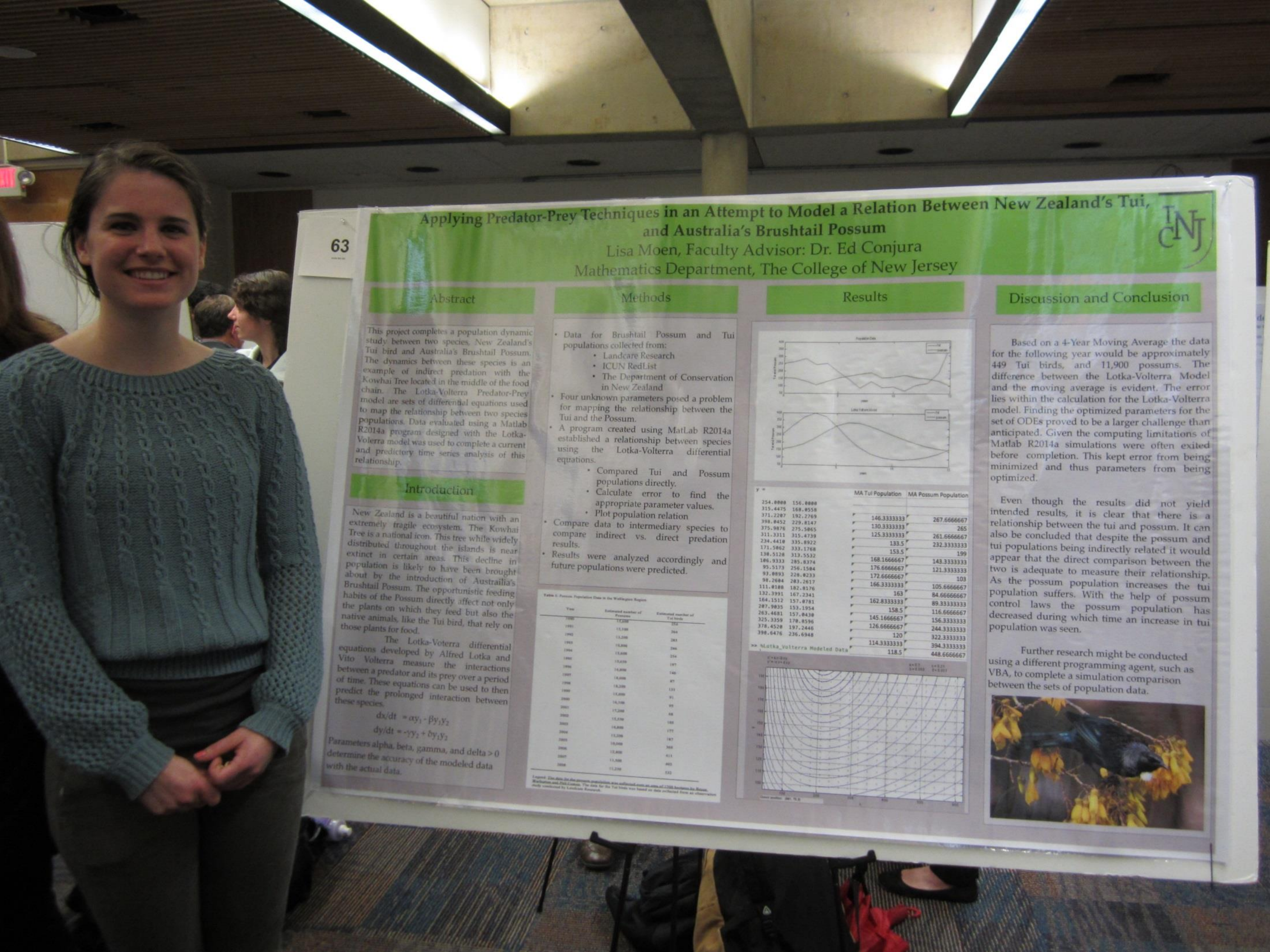
EXIT


Applying Predator-Prey Techniques in an Attempt to Model a Relation Between New Zealand's Tui, and Australia's Brushtail Possum
Lisa Moen, Faculty Advisor: Dr. Ed Conjura
Mathematics Department, The College of New Jersey
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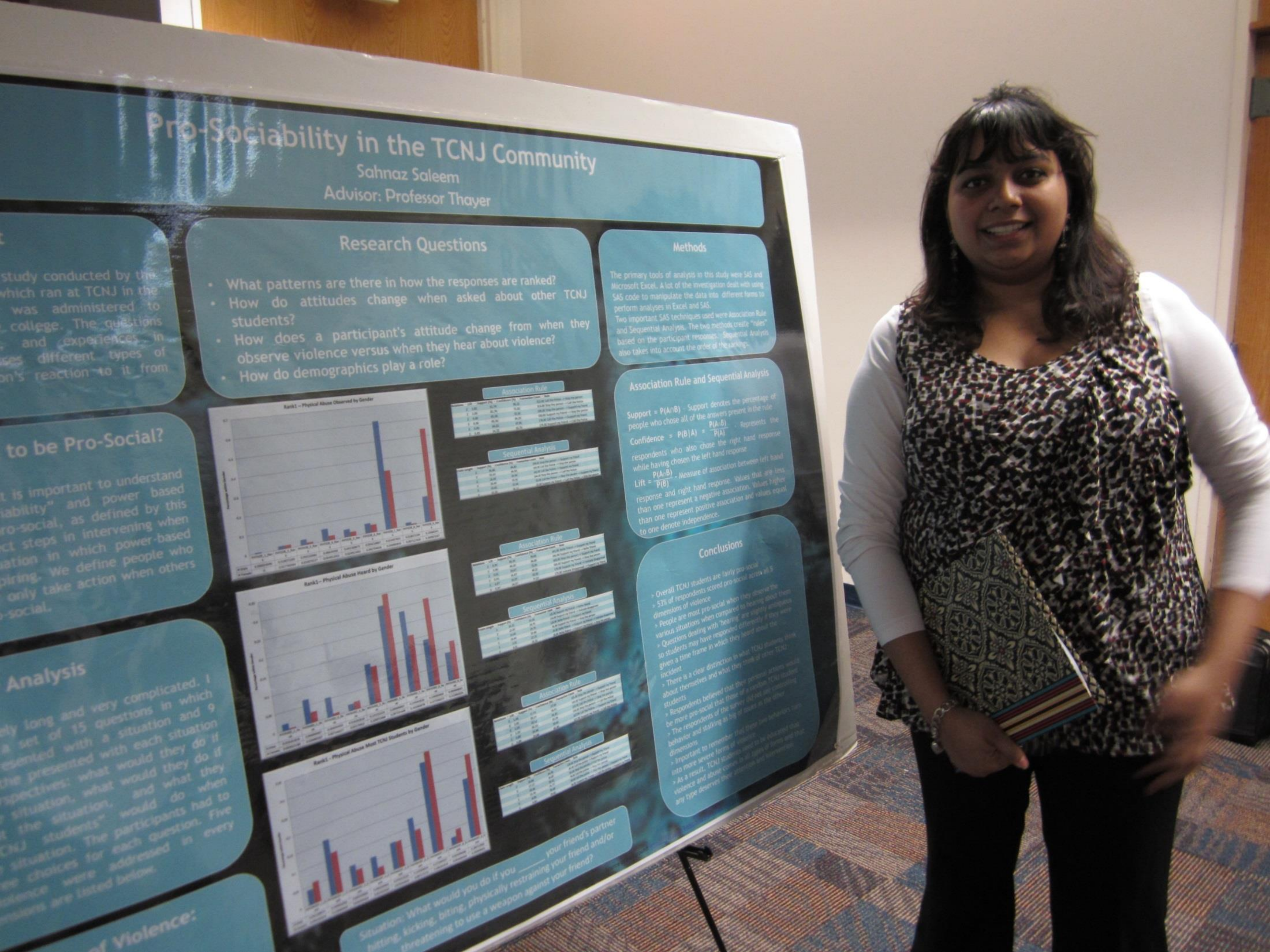
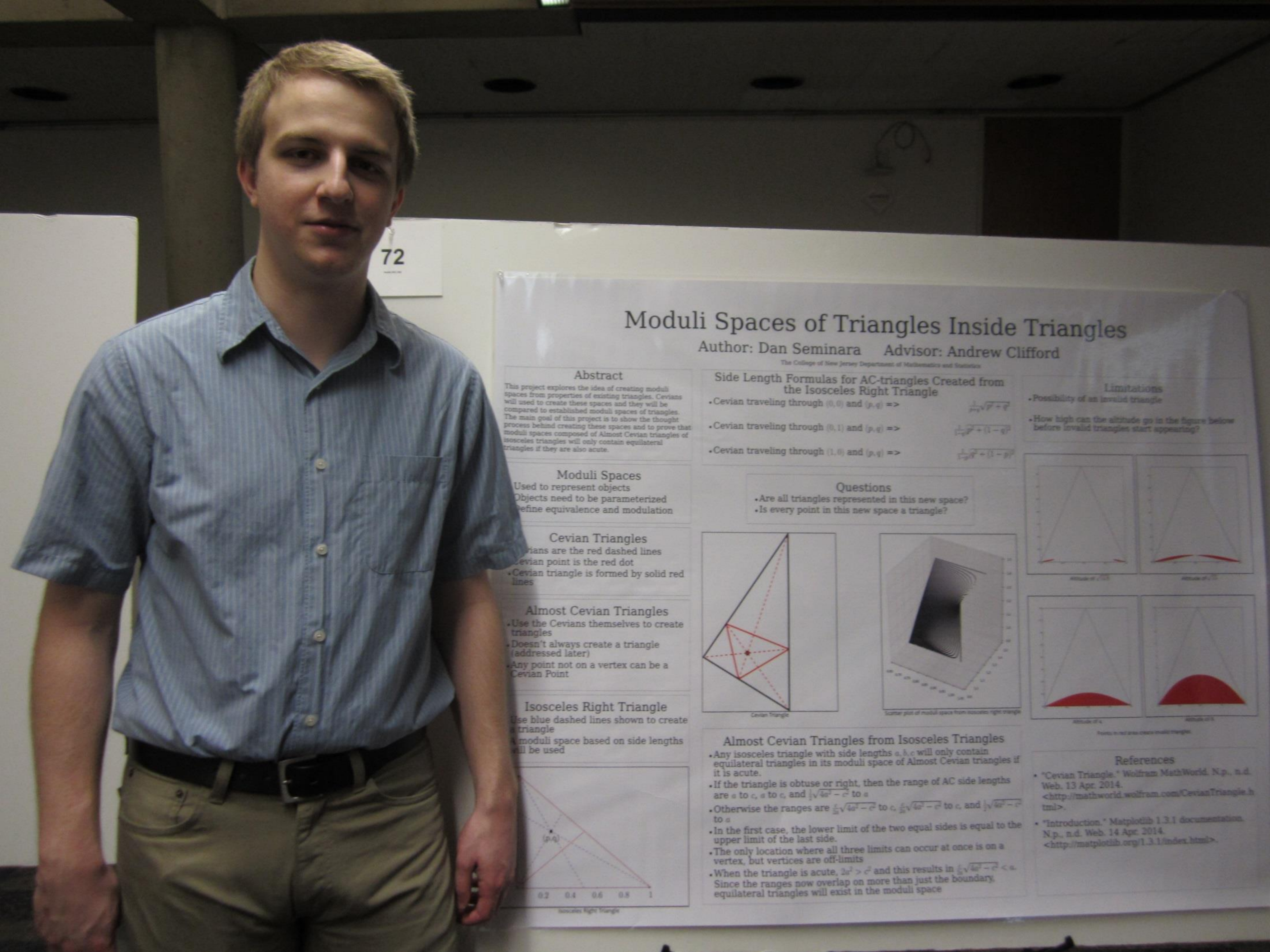
Abstract
This project completes a population dynamic study between two species, New Zealand's Tui bird and Australia's Brushtail Possum. The dynamics between these species is an example of indirect predation with the Kowhai Tree located in the middle of the food chain. The Lotka-Volterra Predator-Prey model are sets of differential equations used to map the relationship between two species populations. Data evaluated using a Matlab R2014a program designed with the Lotka-Volerra model was used to complete a current and predictory time series analysis of this relationship.
Introduction
New Zealand is a beautiful nation with an extremely fragile ecosystem. The Kowhai Tree is a national icon. This tree while widely distributed throughout the islands is near extinct in certain areas. This decline in population is likely to have been brought about by the introduction of Australia's Brushtail Possum. The opportunistic feeding habits of the Possum directly affect not only the plants on which they feed but also the native animals, like the Tui bird, that rely on those plants for food.
The Lotka-Voterra differential equations developed by Alfred Lotka and Vito Volterra measure the interactions between a predator and its prey over a period of time. These equations can be used to then predict the prolonged interaction between these species.
Parameters alpha, beta, gamma, and delta > 0 determine the accuracy of the modeled data with the actual data.
Methods
Data for Brushtail Possum and Tui populations collected from:
Landcare Research
ICUN RedList
The Department of Conservation in New Zealand
Four unknown parameters posed a problem for mapping the relationship between the Tui and the Possum.
A program created using MatLab R2014a established a relationship between species using the Lotka-Volterra differential equations.
Compared Tui and Possum populations directly.
Calculate error to find the appropriate parameter values.
Plot population relation
Compare data to intermediary species to compare indirect vs. direct predation results.
Results were analyzed accordingly and future populations were predicted.
Results
MA Tui Population
MA Possum Population
>> %Lotka_Volterra Modeled Data
Discussion and Conclusion
Based on a 4-Year Moving Average the data for the following year would be approximately 449 Tui birds, and 11,900 possums. The difference between the Lotka-Volterra Model and the moving average is evident. The error lies within the calculation for the Lotka-Volterra model. Finding the optimized parameters for the set of ODEs proved to be a larger challenge than anticipated. Given the computing limitations of Matlab R2014a simulations were often exited before completion. This kept error from being minimized and thus parameters from being optimized.
Even though the results did not yield intended results, it is clear that there is a relationship between the tui and possum. It can also be concluded that despite the possum and tui populations being indirectly related it would appear that the direct comparison between the two is adequate to measure their relationship. As the possum population increases the tui population suffers. With the help of possum control laws the possum population has decreased during which time an increase in tui population was seen.
Further research might be conducted using a different programming agent, such as VBA, to complete a simulation comparison between the sets of population data.


Pro-Sociability in the TCNJ Community
Sahnaz Saleem
Advisor: Professor Thayer
Research Questions
What patterns are there in how the responses are ranked?
How do attitudes change when asked about other TCNJ students?
How does a participant's attitude change from when they observe violence versus when they hear about violence?
How do demographics play a role?
Methods
The primary tools of analysis in this study were SAS and Microsoft Excel. A lot of the investigation dealt with using SAS code to manipulate the data into different forms to perform analyses in Excel and SAS.
Two important SAS techniques used were Association Rule and Sequential Analysis. The two methods create "rules" based on the participant responses. Sequential Analysis also takes into account the order of the rankings.
Association Rule
Sequential Analysis
Association Rule and Sequential Analysis
Conclusions
Situation: What would you do if you ______ your friend's partner hitting, kicking, biting, physically restraining your friend and/or threatening to use a weapon against your friend?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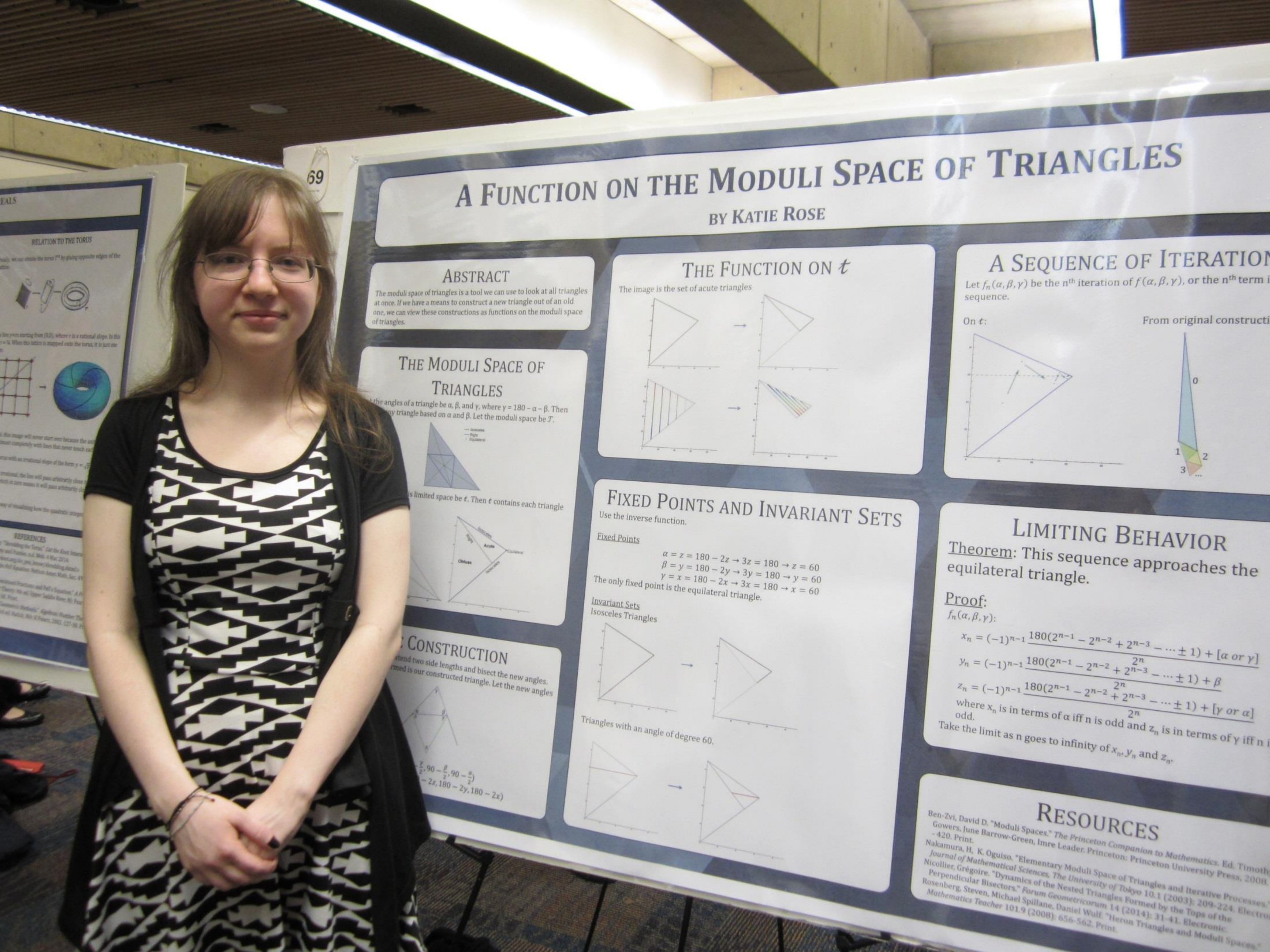
Moduli Spaces of Triangles Inside Triangles
Author: Dan Seminara
Advisor: Andrew Clifford
Abstract
This project explores the idea of creating moduli spaces from properties of existing triangles. Cevians will used to create these spaces and they will be compared to established moduli spaces of triangles. The main goal of this project is to show the thought process behind creating these spaces and to prove that moduli spaces composed of Almost Cevian triangles of isosceles triangles will only contain equilateral triangles if they are also acute.
Moduli Spaces
Used to represent objects
Objects need to be parameterized
Define equivalence and modulation
Cevian Triangles
Cevian point is the red dot
Cevian triangle is formed by solid red lines
Almost Cevian Triangles
Use the Cevians themselves to create triangles
Doesn't always create a triangle (addressed later)
Any point not on a vertex can be a Cevian Point
Isosceles Right Triangle
A moduli space based on side lengths will be used
Side Length Formulas for AC-triangles Created from the Isosceles Right Triangle
Cevian traveling through (0,0) and (p,q) =>
Cevian traveling through (0,1) and (p,q) =>
Cevian traveling through (1,0) and (p,q) =>
Questions
Are all triangles represented in this new space?
Is every point in this new space a triangle?
Limitations
Possibility of an invalid triangle
How high can the altitude go in the figure below before invalid triangles start appearing?
Almost Cevian Triangles from Isosceles Triangles
Any isosceles triangle with side lengths a, b, c will only contain equilateral triangles in its moduli space of Almost Cevian triangles if it is acute.
If the triangle is obtuse or right, then the range of AC side lengths are a to c, a to c, and
In the first case, the lower limit of the two equal sides is equal to the upper limit of the last side.
The only location where all three limits can occur at once is on a vertex, but vertices are off-limits
Since the ranges now overlap on more than just the boundary, equilateral triangles will exist in the moduli space
References
"Cevian Triangle." Wolfram MathWorld. N.p., n.d. Web. 13 Apr. 2014.
"Introduction." Matplotlib 1.3.1 documentation. N.p., n.d. Web. 14 Apr. 2014. <http://matplotlib.org/1.3.1/index.html>.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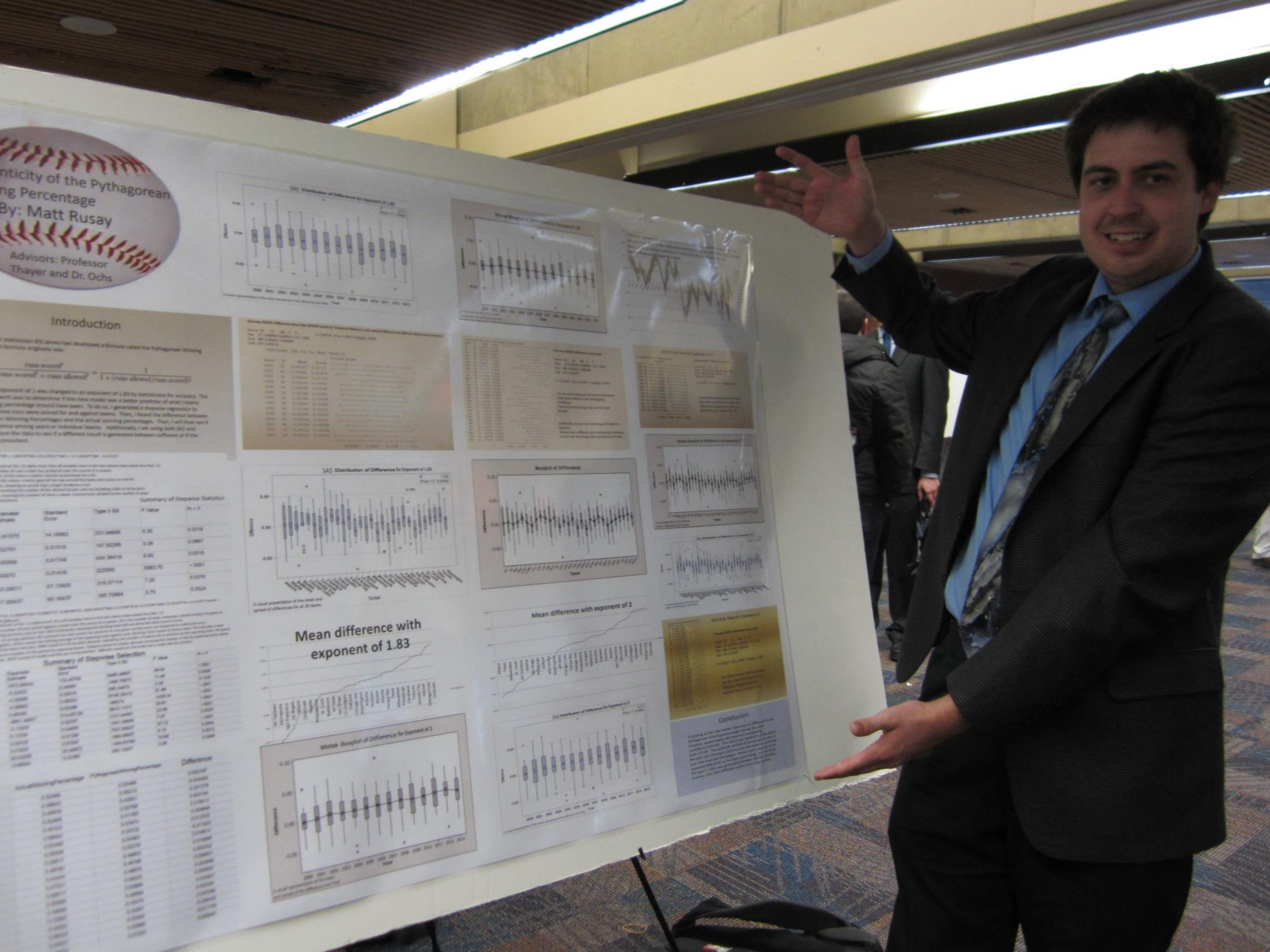
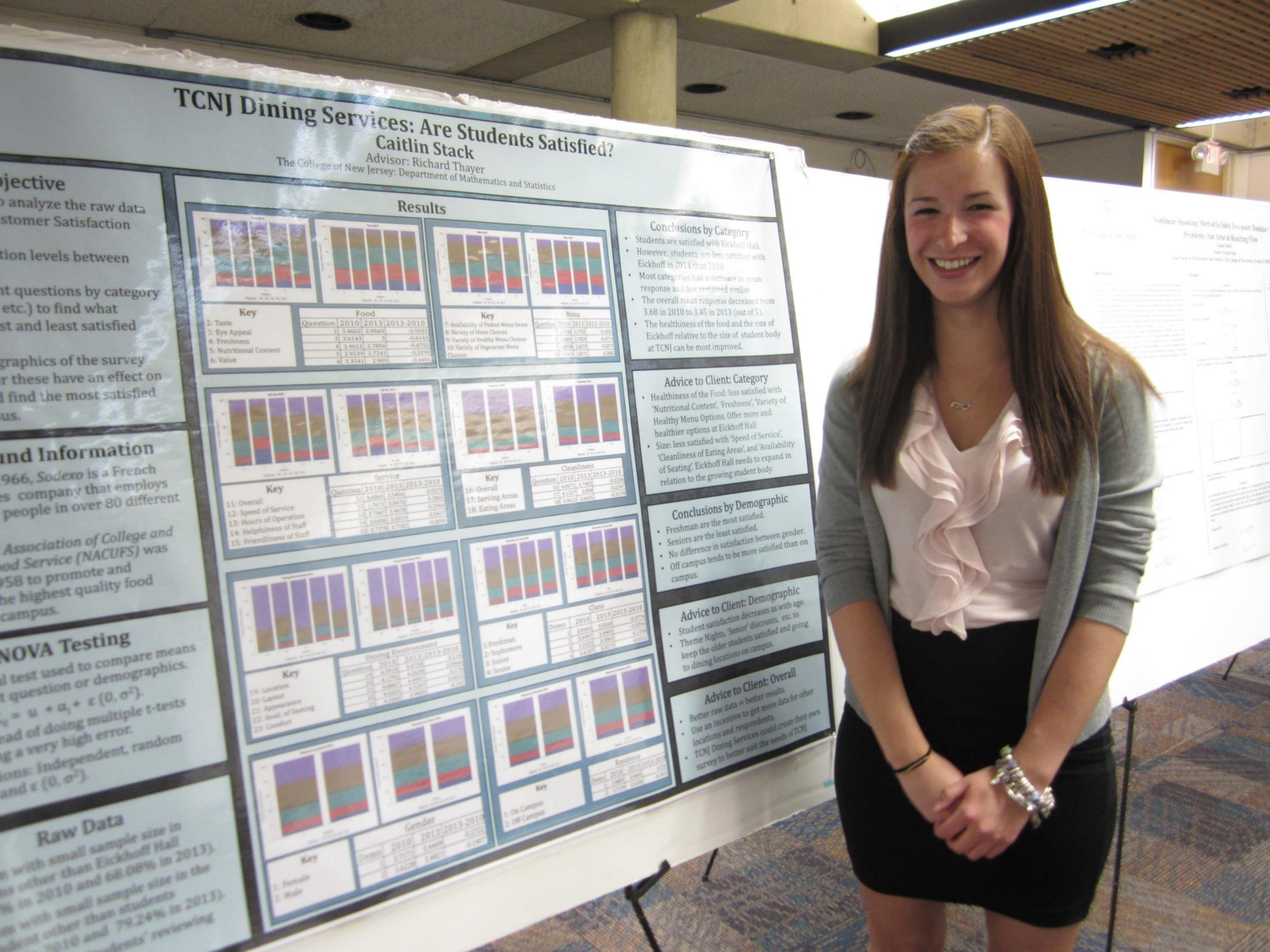
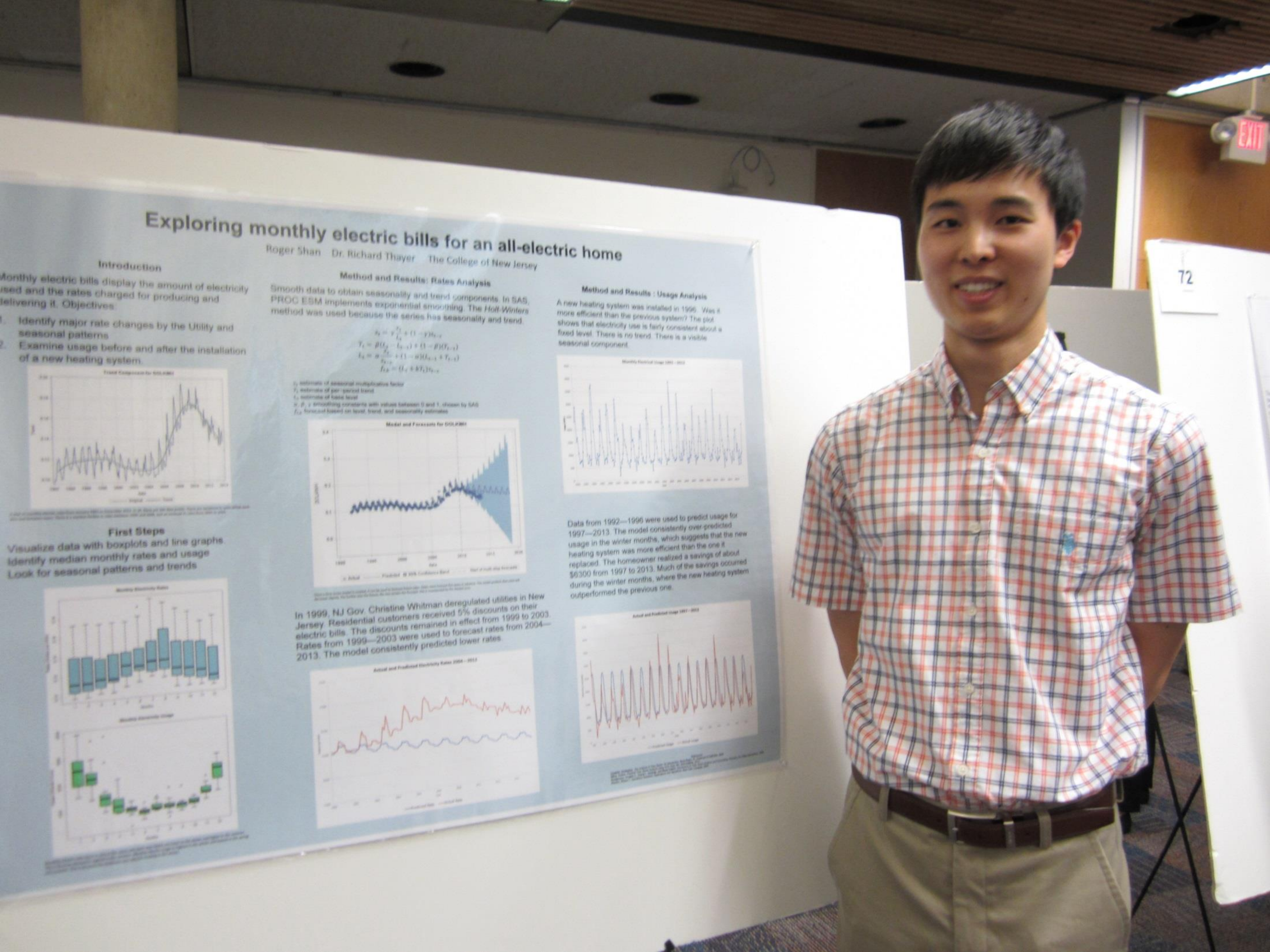
A Function on the Moduli Space of Triangles
by Katie Rose
Abstract
The moduli space of triangles is a tool we can use to look at all triangles at once. If we have a means to construct a new triangle out of an old one, we can view these constructions as functions on the moduli space of triangles.
The Moduli Space of Triangles
Construction
The Function on t
The image is the set of acute triangles
A Sequence of Iteration
sequence.
On t:
Fixed Points and Invariant Sets
Use the inverse function.
Fixed Points
α = z = 180 − 2z → 3z = 180 → z = 60
β = y = 180 − 2y → 3y = 180 → y = 60
γ = x = 180 − 2x → 3x = 180 → x = 60
The only fixed point is the equilateral triangle.
Invariant Sets
Isosceles Triangles
Triangles with an angle of degree 60.
Limiting Behavior
Theorem: This sequence approaches the equilateral triangle.
Proof:
odd.
Resources
Ben-Zvi, David D. "Moduli Spaces." The Princeton Companion to Mathematics.
Gowers, June Barrow-Green, Imre Leader. Princeton: Princeton University Press, 2008.
- 420. Print.
Nakamura, H, K. Oguiso. "Elementary Moduli Space of Triangles and Iterative Processes"
Journal of Mathematical Sciences, The University of Tokyo 10.1 (2003): 209-224.
Nicollier, Grégoire. "Dynamics of the Nested Triangles Formed by the Tops of the Perpendicular Bisectors." Forum Geometricorum 14 (2014): 31-41. Electronic.
Rosenberg, Steven, Michael Spillane, Daniel Wulf. "Heron Triangles and Moduli Spaces."
Mathematics Teacher 101.9 (2008): 656-562. Print.
RELATION TO THE TORUS
REFERENCES


nticity of the Pythagorean
ng Percentage
By: Matt Rusay
Advisors: Professor Thayer and Dr. Ochs
Introduction
Summary of Stepwise Statistics
Boxplot of Difference
Mean difference with exponent of 1.83
Mean difference with exponent of 2
Summary of Stepwise Selection
Minitab Boxplot of Difference for Exponent of 2
Conclusion


TCNJ Dining Services: Are Students Satisfied?
Caitlin Stack
Advisor: Richard Thayer
The College of New Jersey: Department of Mathematics and Statistics
Results
Conclusions by Category
Students are satisfied with Eickhoff Hall.
However, students are less satisfied with Eickhoff in 2013 than 2010
Most categories had a decrease in mean response and few remained similar
The overall mean response decreased from 3.68 in 2010 to 3.45 in 2013 (out of 5).
The healthiness of the food and the size of Eickhoff relative to the size of student body at TCNJ can be most improved.
Advice to Client: Category
Healthiness of the Food: less satisfied with 'Nutritional Content', 'Freshness', 'Variety of Healthy Menu Options. Offer more and healthier options at Eickhoff Hall
Size: less satisfied with 'Speed of Service', 'Cleanliness of Eating Areas', and 'Availability of Seating'. Eickhoff Hall needs to expand in relation to the growing student body.
Conclusions by Demographic
Freshman are the most satisfied.
Seniors are the least satisfied.
No difference in satisfaction between gender.
Off campus tends to be more satisfied than on campus.
Advice to Client: Demographic
Student satisfaction decreases as with age.
Theme Nights, 'Senior' discounts, etc. to keep the older students satisfied and going to dining locations on campus.
Advice to Client: Overall
Better raw data = better results.
Use an incentive to get more data for other locations and respondents.
TCNJ Dining Services could create their own survey to better suit the needs of TCNJ
Key
2: Taste
3: Eye Appeal
4: Freshness
5: Nutritional Content
6: Value
Food
Menu
Service
Cleanliness
Class
Dining Environment
Residence
Gender
1: On Campus
2: Off Campus
Raw Data
NOVA Testing


Exploring monthly electric bills for an all-electric home
Roger Shan Dr. Richard Thayer The College of New Jersey
Introduction
Monthly electric bills display the amount of electricity used and the rates charged for producing and delivering it. Objectives:
1. Identify major rate changes by the Utility and seasonal patterns
2. Examine usage before and after the installation of a new heating system
First Steps
Visualize data with boxplots and line graphs
Identify median monthly rates and usage
Look for seasonal patterns and trends
Method and Results: Rates Analysis
Smooth data to obtain seasonality and trend components. In SAS, PROC ESM implements exponential smoothing. The Holt-Winters method was used because the series has seasonality and trend.
Model and Forecasts for DOLKWH
In 1999, NJ Gov. Christine Whitman deregulated utilities in New Jersey. Residential customers received 5% discounts on their electric bills. The discounts remained in effect from 1999 to 2003. Rates from 1999—2003 were used to forecast rates from 2004—2013. The model consistently predicted lower rates.
Method and Results : Usage Analysis
A new heating system was installed in 1996. Was it more efficient than the previous system? The plot shows that electricity use is fairly consistent about a fixed level. There is no trend. There is a visible seasonal component.
Data from 1992—1996 were used to predict usage for 1997—2013. The model consistently over-predicted usage in the winter months, which suggests that the new heating system was more efficient than the one it replaced. The homeowner realized a savings of about $6300 from 1997 to 2013. Much of the savings occurred during the winter months, where the new heating system outperformed the previous one.
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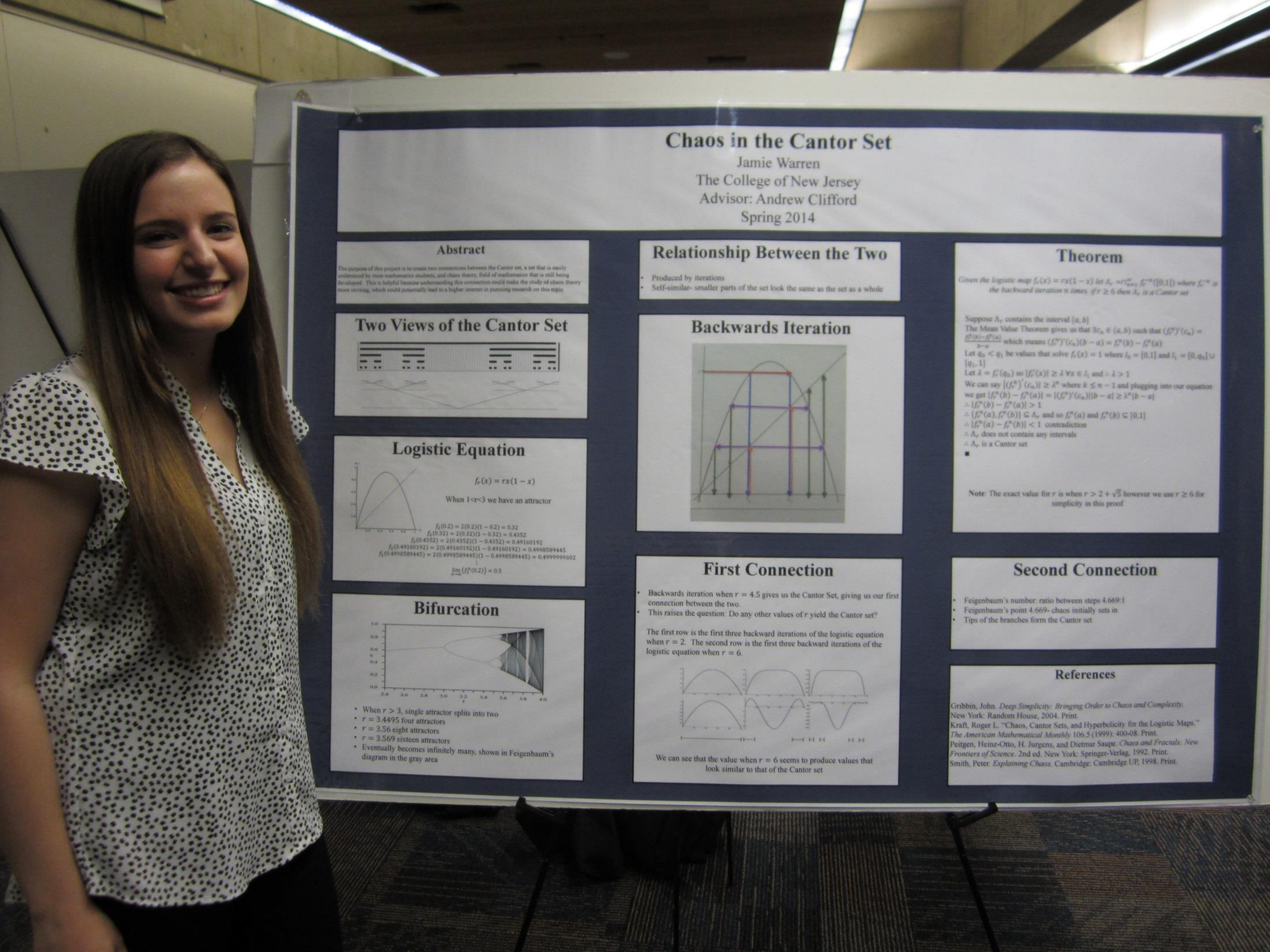
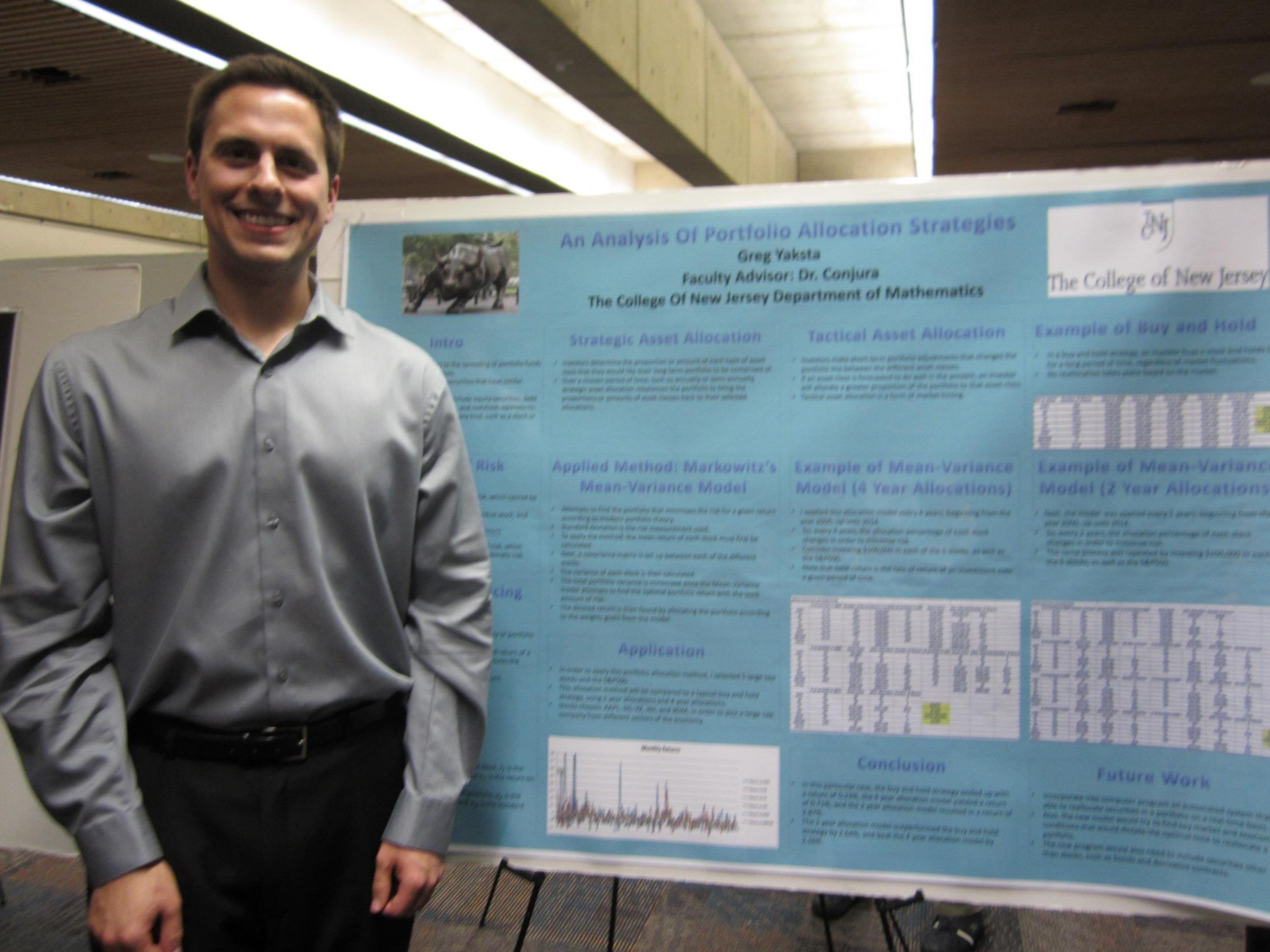
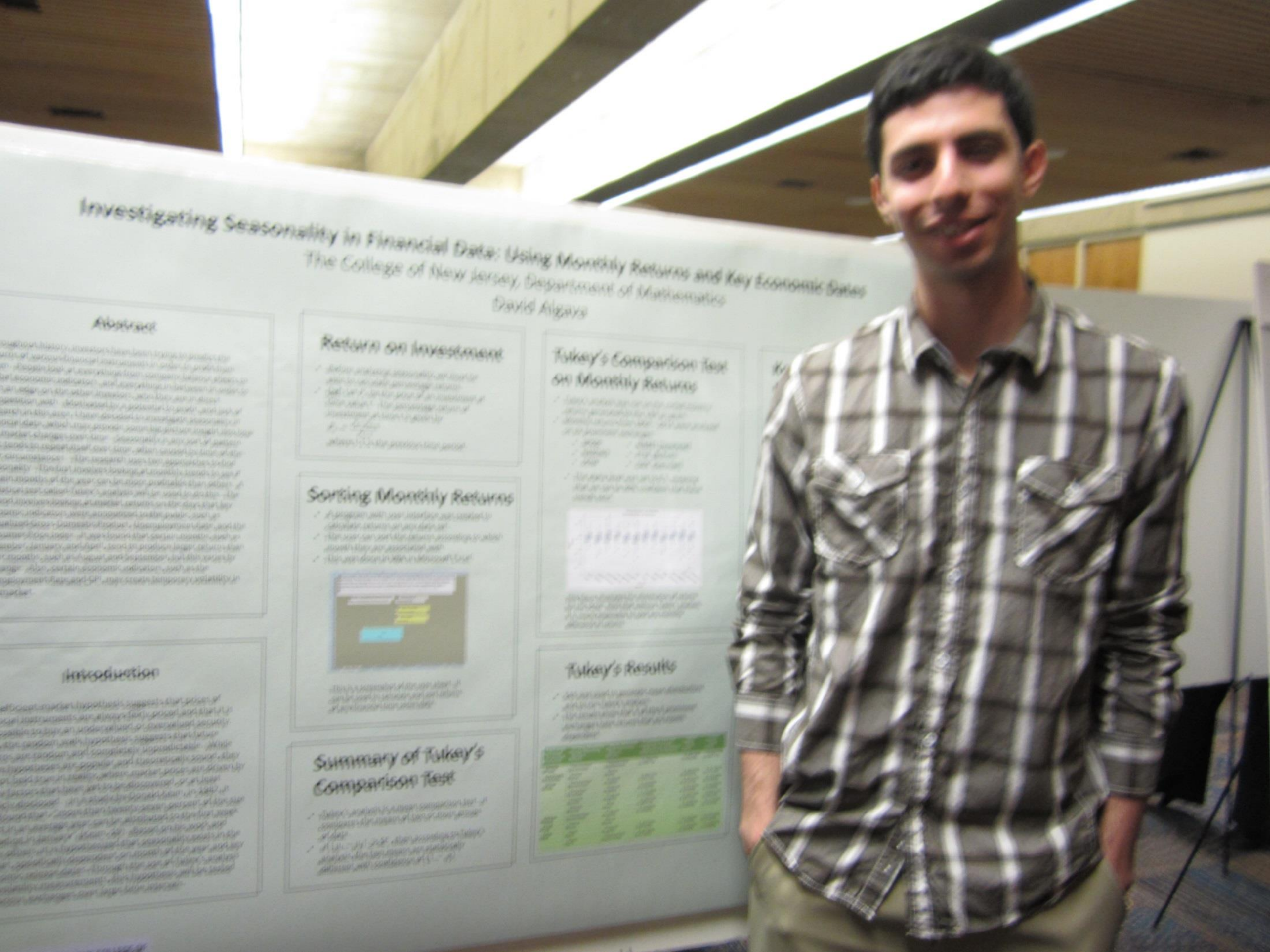
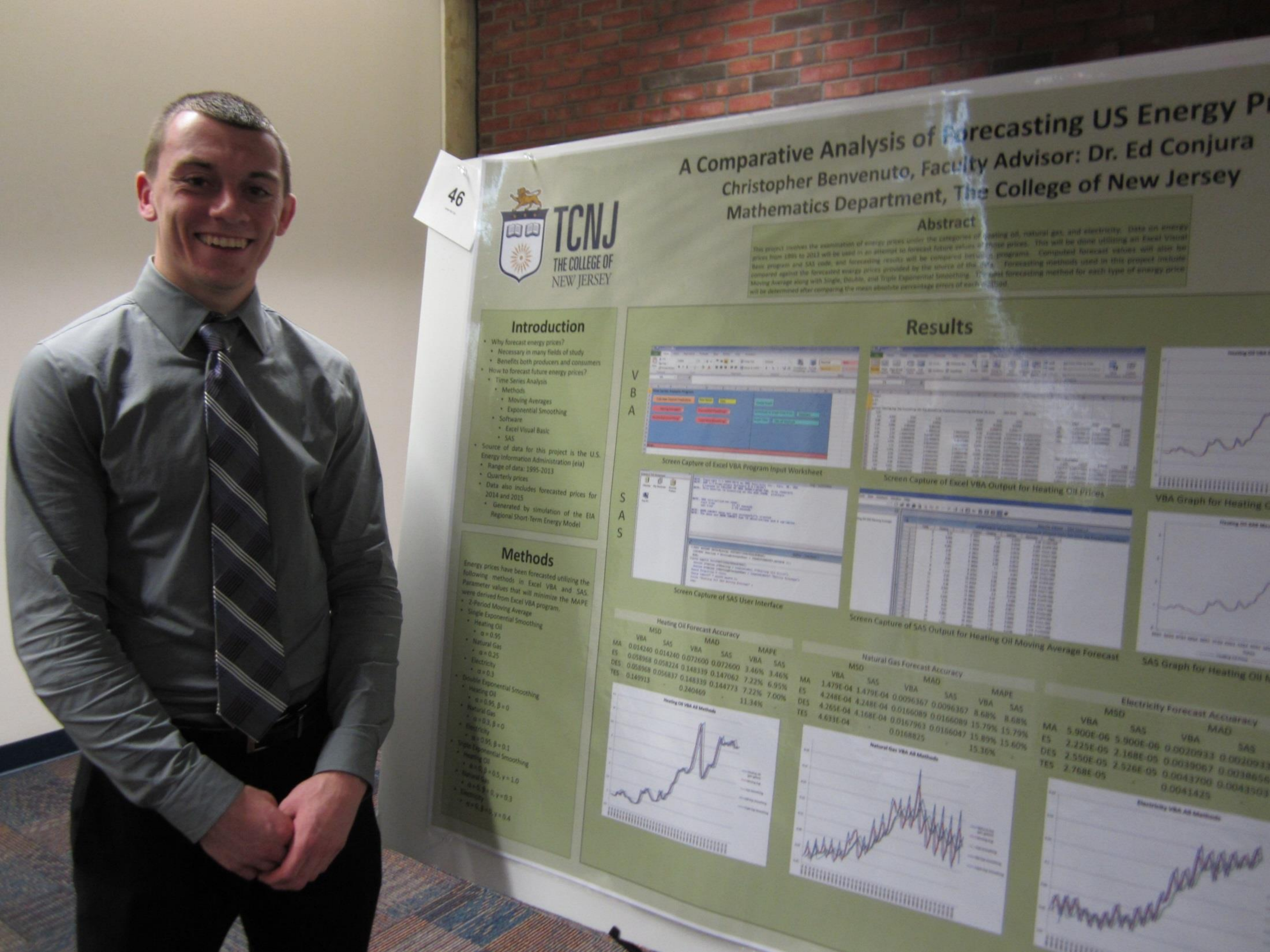
EXIT


Chaos in the Cantor Set
Jamie Warren
The College of New Jersey
Advisor: Andrew Clifford
Spring 2014
Abstract
The purpose of this project is to create two connections between the Cantor set, a set that is easily understood by most mathematics students, and chaos theory, field of mathematics that is still being developed. This is helpful because understanding this connection could make the study of chaos theory more inviting, which could potentially lead to a higher interest in pursuing research on this topic.
Two Views of the Cantor Set
Logistic Equation
$f_r(x) = rx(1-x)$
When 1<r<3 we have an attractor
Bifurcation
When $r > 3$, single attractor splits into two
$r = 3.4495$ four attractors
$r = 3.56$ eight attractors
$r = 3.569$ sixteen attractors
Eventually becomes infinitely many, shown in Feigenbaum's diagram in the gray area
Relationship Between the Two
Produced by iterations
Self-similar- smaller parts of the set look the same as the set as a whole
Backwards Iteration
First Connection
Backwards iteration when $r = 4.5$ gives us the Cantor Set, giving us our first connection between the two.
This raises the question: Do any other values of r yield the Cantor set?
The first row is the first three backward iterations of the logistic equation when $r = 2$. The second row is the first three backward iterations of the logistic equation when $r = 6$.
We can see that the value when $r = 6$ seems to produce values that look similar to that of the Cantor set
Theorem
Given the logistic map $f_r(x) = rx(1-x)$ let $A_r = \cap_{n=1}^{\infty} f_r^{-n}([0,1])$ where f_r^{-n} is the backward iteration n times. if $r \geq 6$ then A_r is a Cantor set
Suppose A_r contains the interval $[a, b]$
$\therefore A_r$ does not contain any intervals
$\therefore A_r$ is a Cantor set
Note: The exact value for r is when $r > 2 + \sqrt{5}$ however we use $r \geq 6$ for simplicity in this proof
Second Connection
Feigenbaum's number: ratio between steps 4.669:1
Feigenbaum's point 4.669- chaos initially sets in
Tips of the branches form the Cantor set
References
Gribbin, John. Deep Simplicity: Bringing Order to Chaos and Complexity. New York: Random House, 2004. Print.
Kraft, Roger L. "Chaos, Cantor Sets, and Hyperbolicity for the Logistic Maps." The American Mathematical Monthly 106.5 (1999): 400-08. Print.
Peitgen, Heinz-Otto, H. Jurgens, and Dietmar Saupe. Chaos and Fractals: New Frontiers of Science. 2nd ed. New York: Springer-Verlag, 1992. Print.
Smith, Peter. Explaining Chaos. Cambridge: Cambridge UP, 1998. Print.


An Analysis Of Portfolio Allocation Strategies
Greg Yaksta
Faculty Advisor: Dr. Conjura
The College Of New Jersey Department of Mathematics
Intro
Strategic Asset Allocation
Tactical Asset Allocation
Example of Buy and Hold
Risk
Applied Method: Markowitz's Mean-Variance Model
Example of Mean-Variance Model (4 Year Allocations)
Application
Conclusion
Future Work


Automorphisms of Lie Groups
Joseph Zambrano


Investigating Seasonality in Financial Data: Using Monthly Returns and Key Economic Dates
The College of New Jersey, Department of Mathematics
Abstract
Return on Investment
Tukey's Comparison Test on Monthly Returns
Sorting Monthly Returns
Introduction
Tukey's Results
Summary of Tukey's Comparison Test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A Comparative Analysis of orecasting US Energy Pr
Christopher Benvenuto, Faculty Advisor: Dr. Ed Conjura
Mathematics Department, The College of New Jersey
TCNJ
THE COLLEGE OF
NEW JERSEY
Abstract
Introduction
Why forecast energy prices?
Necessary in many fields of study
Benefits both producers and consumers
How to forecast future energy prices?
Time Series Analysis
Methods
Moving Averages
Exponential Smoothing
Software
Excel Visual Basic
SAS
Source of data for this project is the U.S. Energy Information Administration (eia)
Range of data: 1995-2013
Quarterly prices
Data also includes forecasted prices for 2014 and 2015
Generated by simulation of the EIA Regional Short-Term Energy Model
Methods
Results
VBA
SAS
Screen Capture of Excel VBA Program Input Worksheet
Screen Capture of Excel VBA Output for Heating Oil Prices
Screen Capture of SAS User Interface
Screen Capture of SAS Output for Heating Oil Moving Average Forecast
Heating Oil Forecast Accuracy
Natural Gas Forecast Accuracy
Electricity Forecast Accuracy
Heating Oil VBA All Methods
Natural Gas VBA All Methods
Electricity VBA All Methods


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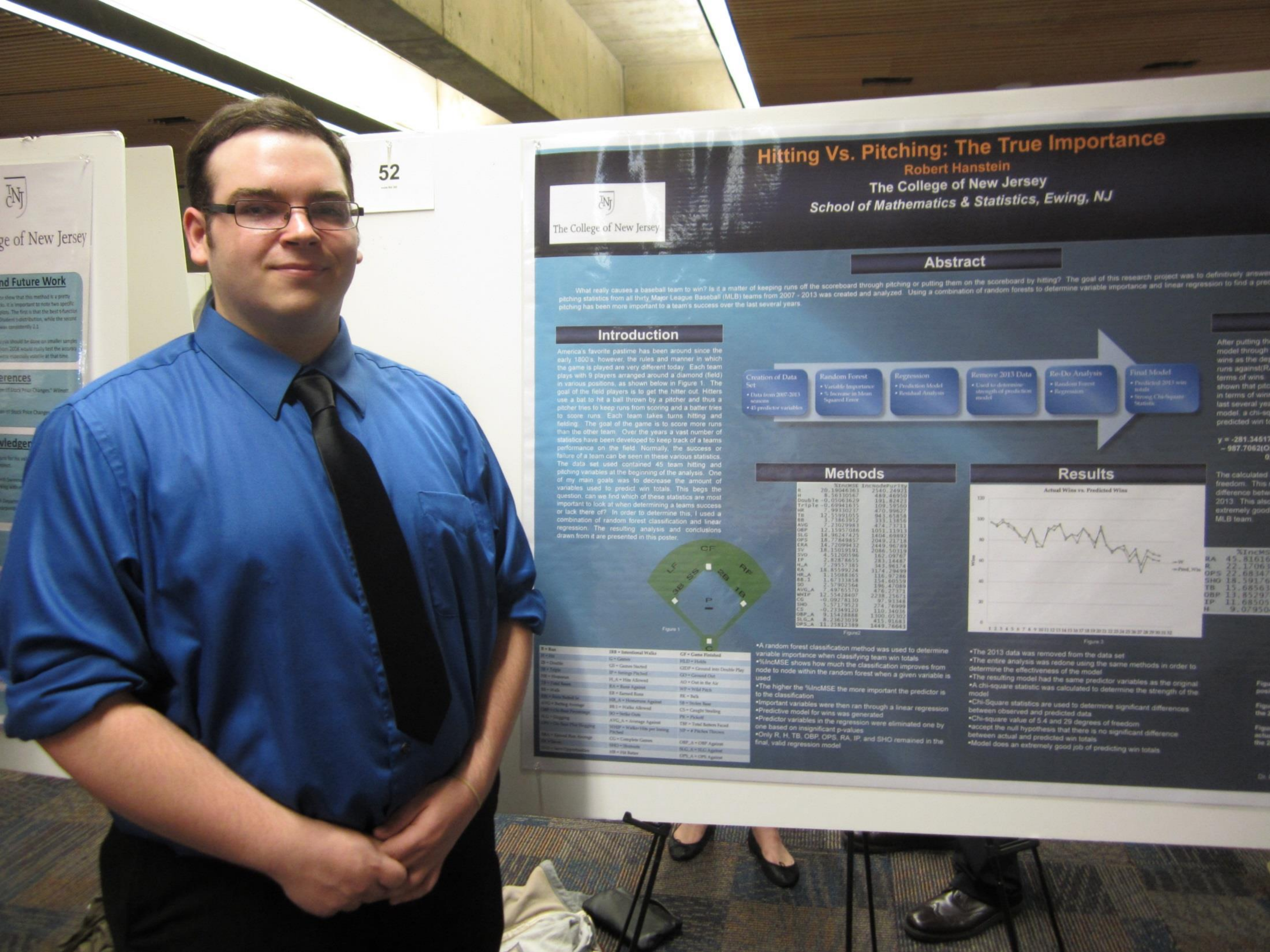
Exploring Seasonality in the Stock Mark
Darren Carbone, Department of Mathematics and Statistics, The C
Faculty Advisor: Dr. Edward Conjura
Introduction
Many people invest in the stock market, but not many people know how to effectively predict the market. For the most part this is not ignorance but the fact that it is just difficult to predict the market, and even after getting a decent model the market is constantly changing and thus many of the model will be obsolete eventually. It all starts with that question. How can we better predict the market? Well that is where this project come in.
This project is being conducted to investigate a seasonal component in the market that can help us better predict future stock prices, and returns. Seasonality is any predictable change that occurs during any period of time. Seasonality within a year can be monthly, quarterly, bi-annually, etc. We can investigate the seasonal component of a time series through modeling or the use of other statistical methods to determine how seasonality, if there is any, is effecting stock prices and returns. Out of the many options this project will be using Tukey's Method, and a Holt-Winters Model.
Technology was a vital part in the execution of this project as many of the calculations and data manipulations are difficult, if not impossible, to do by hand. In particular, SAS was used for the modeling and statistical test, while Visual Basic was used to deal with sorting issues, and making calculations.
Methods
Tukey's Method
Methods con't
Holt-Winters Model
Developed by C.C. Holt and his student Peter Winters
The Holt-Winters Model is a smoothing model that takes into account seasonality
There is an additive and a multiplicative Holt-Winters Model
They are both comprised of three equations that are used to get the forecasted values
The three equations are the overall smoothing (E_t), the trend estimation (T_t), and the seasonal index (S_t), along with the forecast(F_t)
For the multiplicative model they are
$E_t = \frac{y_t}{S_{t-L}} + (1-\alpha) * (E_{t-1} + T_{t-1})$
$T_t = \beta * (E_t - E_{t-1}) + (1-\beta) * T_{t-1}$
$S_t = \gamma * \left(\frac{y_t}{E_t}\right) + (1-\gamma) * S_{t-L}$
Where α, β, and γ are constant weights between 0 and 1, t is time, and L is the length of the seasonal period
When α, β, and γ are large there is more weight given to more recent observations
The forecast for time t+M are given by
$F_{t+M} = (E_{t-1} + M * T_{t-1})S_{t+M-L}$
Where M is how far into the future you want to forecast
Using SAS, Holt- Winters will be used to compare market indexes with seasonality and without both with best observed parameters (Lowest root mean squared error)
Results
Tukey's test with alpha = .10
INDEX
Significant Difference
S&P 500
September and December
Nikkei
August and December
Dow
March and May
March and August
August and October
August and November
DAX
April and August
April and September
Results Con'
Index
Parameters
S&P 500
$\alpha = .76$
$\beta = .05$
$\gamma = .44$
Dow
$\alpha = .76$
$\beta = .08$
$\gamma = .18$
NASDAQ
$\alpha = .80$
$\beta = .10$
$\gamma = .25$
Index
Parameters
S&P 500
$\alpha = .90$
$\beta = .09$
28.70
Dow
$\alpha = .92$
$\beta = .06$
244.81
NASDAQ
$\alpha = .87$
$\beta = .05$
121.71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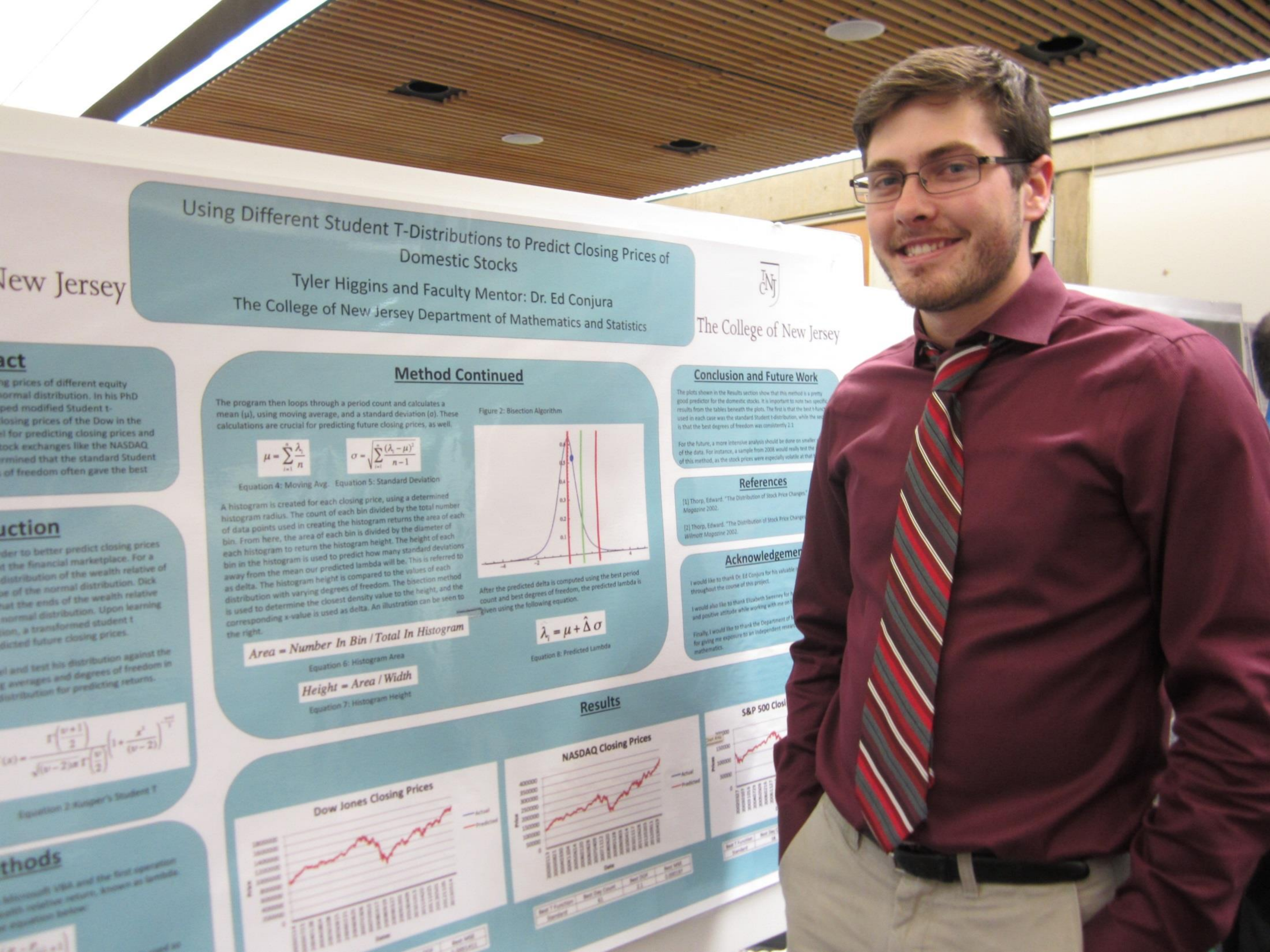
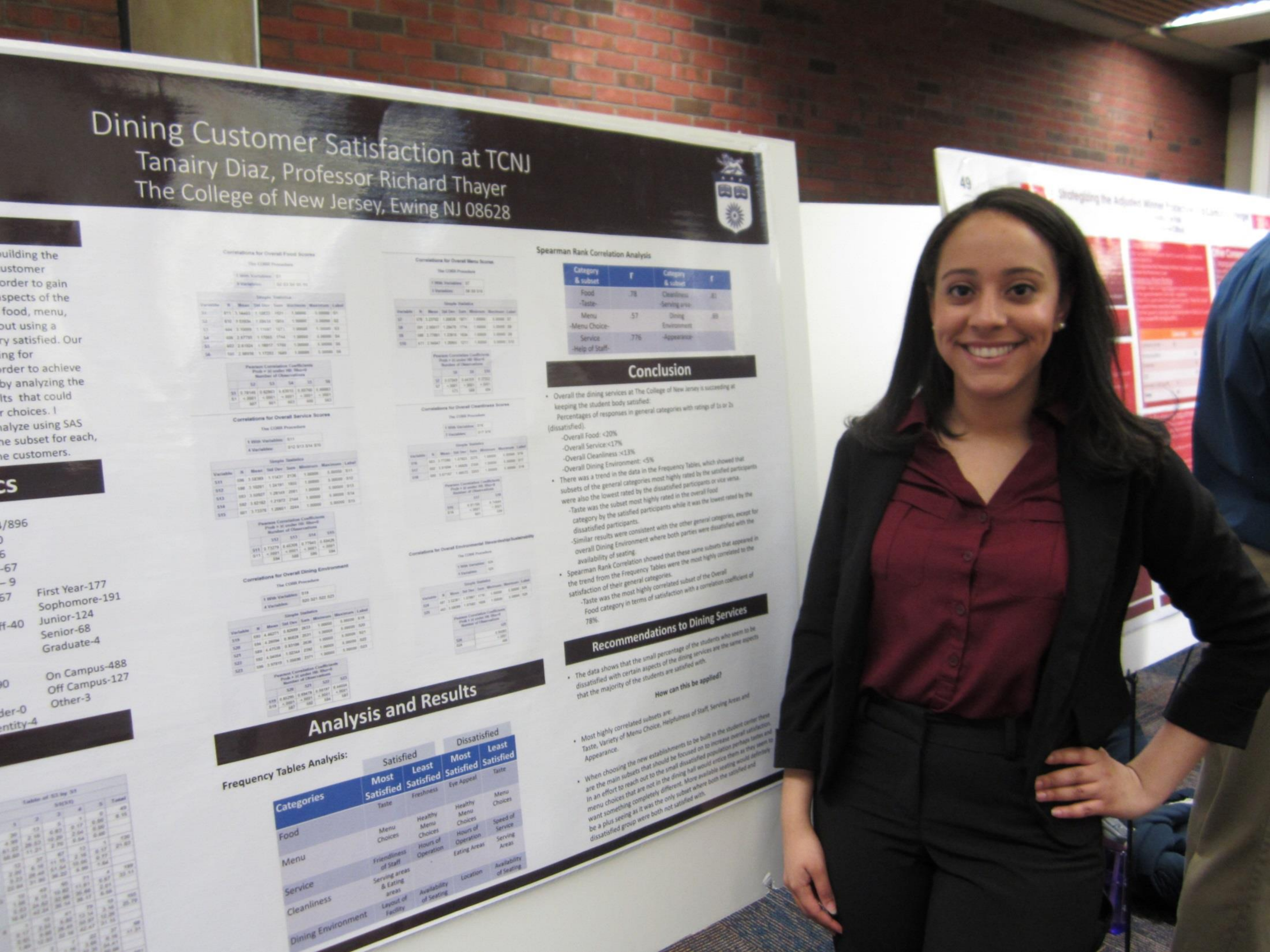
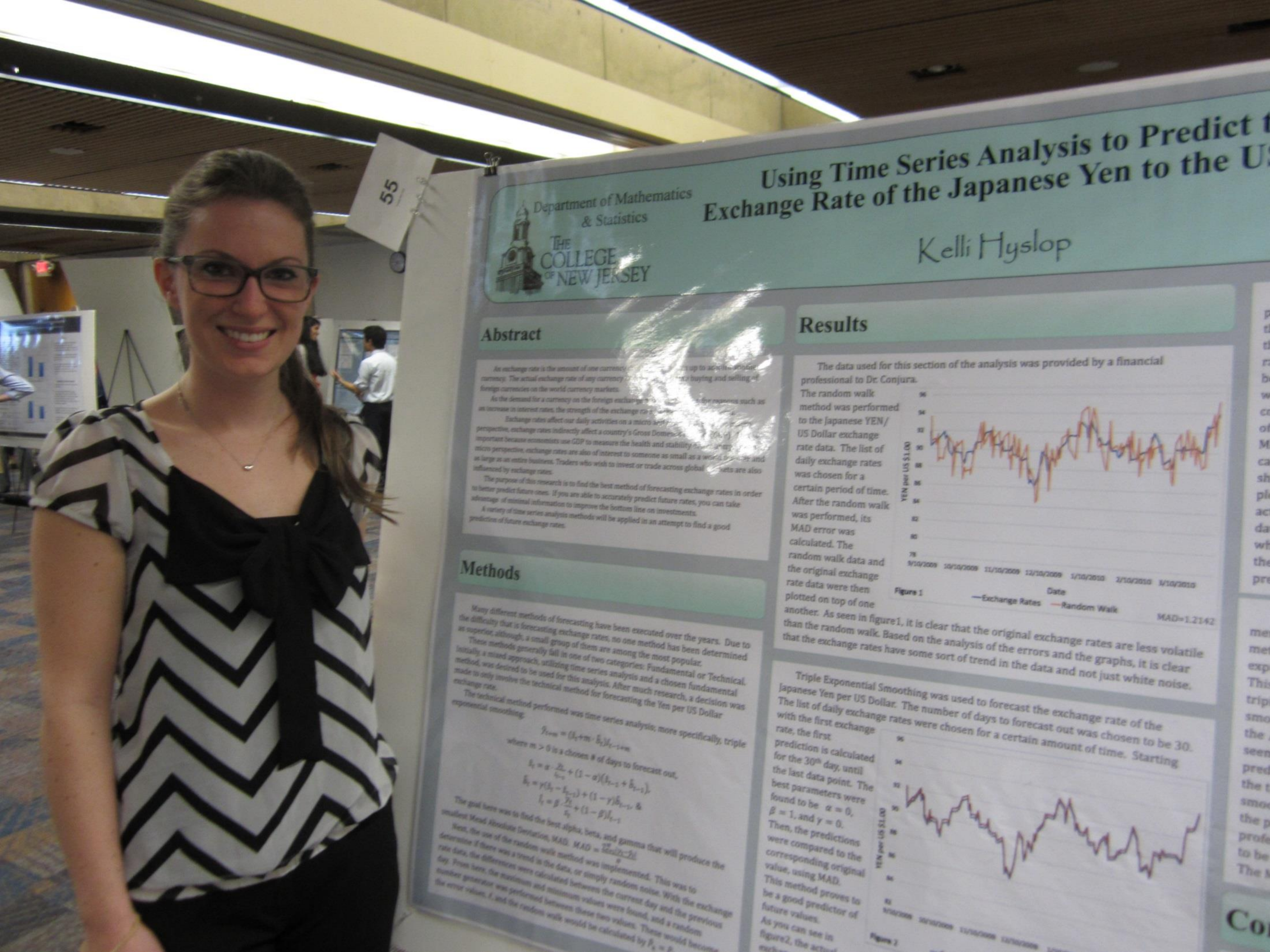
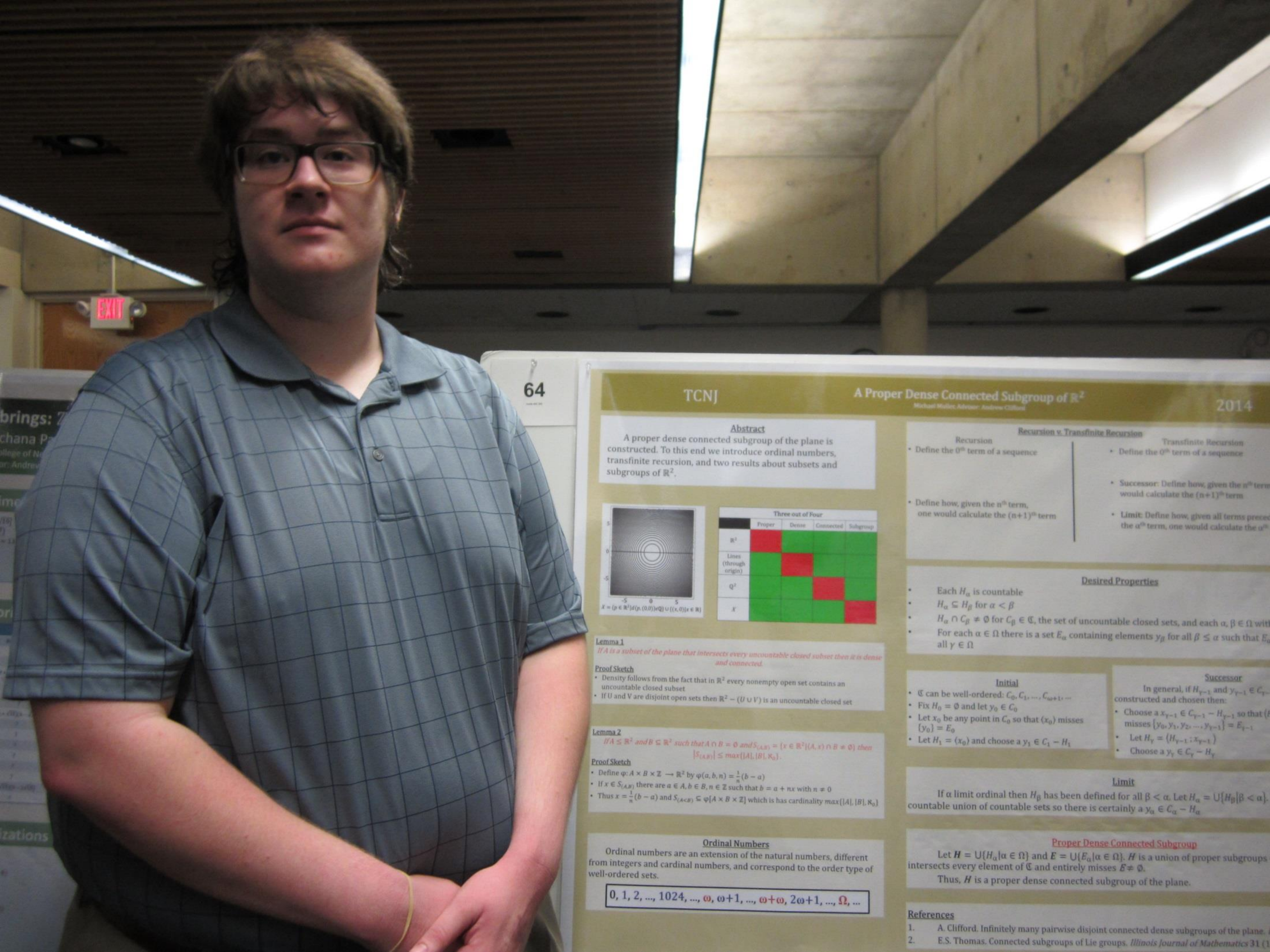
Hitting Vs. Pitching: The True Importance
Robert Hanstein
The College of New Jersey
School of Mathematics & Statistics, Ewing, NJ
The College of New Jersey
Abstract
Introduction
Creation of Data Set
Random Forest
Regression
Remove 2013 Data
Re-Do Analysis
Final Model
Methods
Results
Actual Wins vs. Predicted Wins
•A random forest classification method was used to determine variable importance when classifying team win totals
•%IncMSE shows how much the classification improves from node to node within the random forest when a given variable is used
•The higher the %IncMSE the more important the predictor is to the classification
•Important variables were then ran through a linear regression
•Predictive model for wins was generated
•Predictor variables in the regression were eliminated one by one based on insignificant p-values
•Only R, H, TB, OBP, OPS, RA, IP, and SHO remained in the final, valid regression model
•The 2013 data was removed from the data set
•The entire analysis was redone using the same methods in order to determine the effectiveness of the model
•The resulting model had the same predictor variables as the original
•A chi-square statistic was calculated to determine the strength of the model
•Chi-Square statistics are used to determine significant differences between observed and predicted data
•Chi-square value of 5.4 and 29 degrees of freedom
•accept the null hypothesis that there is no significant difference between actual and predicted win totals
•Model does an extremely good job of predicting win totals
nd Future Work
erences
ge of New Jersey


Using Different Student T-Distributions to Predict Closing Prices of Domestic Stocks
Tyler Higgins and Faculty Mentor: Dr. Ed Conjura
The College of New Jersey Department of Mathematics and Statistics
The College of New Jersey
Method Continued
The program then loops through a period count and calculates a mean (μ), using moving average, and a standard deviation (σ). These calculations are crucial for predicting future closing prices, as well.
Equation 4: Moving Avg.
Equation 5: Standard Deviation
Figure 2: Bisection Algorithm
After the predicted delta is computed using the best period count and best degrees of freedom, the predicted lambda is given using the following equation.
Equation 8: Predicted Lambda
Area = Number In Bin / Total In Histogram
Equation 6: Histogram Area
Height = Area / Width
Equation 7: Histogram Height
Conclusion and Future Work
References
Results
NASDAQ Closing Prices
Dow Jones Closing Prices


Dining Customer Satisfaction at TCNJ
Tanairy Diaz, Professor Richard Thayer
The College of New Jersey, Ewing NJ 08628
Spearman Rank Correlation Analysis
Conclusion
Recommendations to Dining Services
How can this be applied?
Analysis and Results
Frequency Tables Analysis:
Satisfied
Dissatisfied
Most Satisfied
Least Satisfied
Categories
Food
Menu
Service
Cleanliness
Dining Environment
First Year-177
Sophomore-191
Junior-124
Senior-68
Graduate-4
On Campus-488
Off Campus-127
Other-3
49


55
Using Time Series Analysis to Predict t
Exchange Rate of the Japanese Yen to the U
Department of Mathematics & Statistics
THE COLLEGE OF NEW JERSEY
Kelli Hyslop
Abstract
Methods
Results
The data used for this section of the analysis was provided by a financial professional to Dr. Conjura.
The random walk method was performed to the Japanese YEN/ US Dollar exchange rate data. The list of daily exchange rates was chosen for a certain period of time. After the random walk was performed, its MAD error was calculated. The random walk data and the original exchange rate data were then plotted on top of one another. As seen in figure1, it is clear that the original exchange rates are less volatile than the random walk. Based on the analysis of the errors and the graphs, it is clear that the exchange rates have some sort of trend in the data and not just white noise.
YEN per US $1.00
Date
Figure 1
Exchange Rates
Random Walk
MAD=1.2142
Triple Exponential Smoothing was used to forecast the exchange rate of the Japanese Yen per US Dollar. The number of days to forecast out was chosen to be 30. The list of daily exchange rates were chosen for a certain amount of time. Starting with the first exchange rate, the first prediction is calculated for the 30th day, until the last data point. The best parameters were found to be α = 0, β = 1, and γ = 0. Then, the predictions were compared to the corresponding original value, using MAD. This method proves to be a good predictor of future values. As you can see in figure2, the actual
YEN per US $1.00
Figure 2


EXIT
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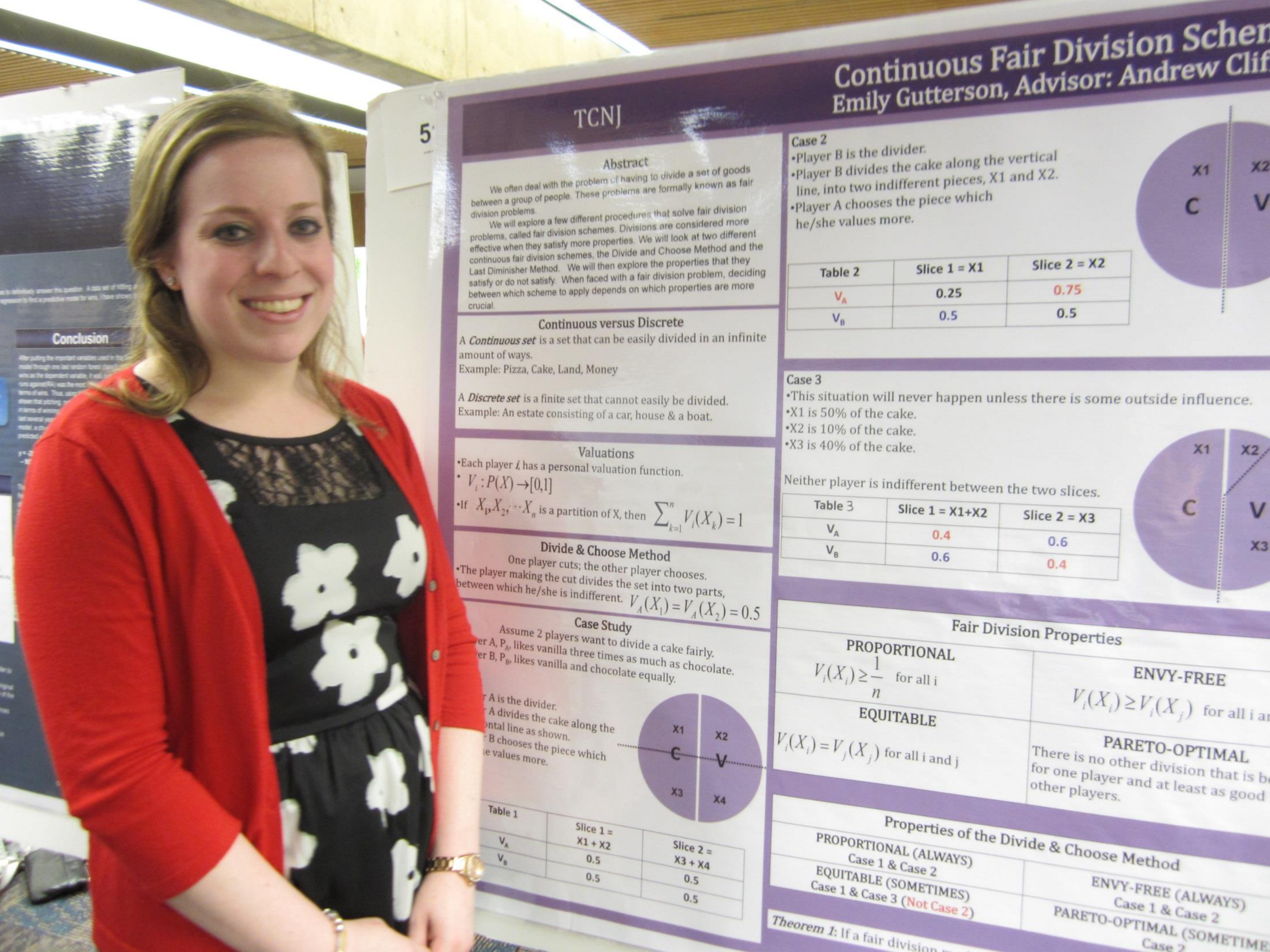
TCNJ
A Proper Dense Connected Subgroup of ℝ²
2014
Abstract
A proper dense connected subgroup of the plane is constructed. To this end we introduce ordinal numbers, transfinite recursion, and two results about subsets and subgroups of ℝ².
Three out of Four
Proper
Dense
Connected
Subgroup
ℝ²
Lines (through origin)
ℚ²
X
Lemma 1
Proof Sketch
Lemma 2
Proof Sketch
Ordinal Numbers
Ordinal numbers are an extension of the natural numbers, different from integers and cardinal numbers, and correspond to the order type of well-ordered sets.
0, 1, 2, ..., 1024, ..., ω, ω+1, ..., ω+ω, 2ω+1, ..., Ω, ...
Recursion v. Transfinite Recursion
Recursion
Define the 0th term of a sequence
Define how, given the nth term, one would calculate the (n+1)th term
Transfinite Recursion
Define the 0th term of a sequence
Desired Properties
Each Hα is countable
Initial
Successor
Limit
Proper Dense Connected Subgroup
Thus, H is a proper dense connected subgroup of the plane.
References


Continuous Fair Division Schen
Emily Gutterson, Advisor: Andrew Clif
TCNJ
Abstract
We often deal with the problem of having to divide a set of goods between a group of people. These problems are formally known as fair division problems.
We will explore a few different procedures that solve fair division problems, called fair division schemes. Divisions are considered more effective when they satisfy more properties. We will look at two different continuous fair division schemes, the Divide and Choose Method and the Last Diminisher Method. We will then explore the properties that they satisfy or do not satisfy. When faced with a fair division problem, deciding between which scheme to apply depends on which properties are more crucial.
Continuous versus Discrete
A Continuous set is a set that can be easily divided in an infinite amount of ways.
Example: Pizza, Cake, Land, Money
A Discrete set is a finite set that cannot easily be divided.
Example: An estate consisting of a car, house & a boat.
Valuations
•Each player i, has a personal valuation function.
• $V_i : P(X) \rightarrow [0,1]$
•If $X_1, X_2, \cdots X_n$ is a partition of X, then $\sum_{k=1}^{n} V_i(X_k) = 1$
Divide & Choose Method
One player cuts; the other player chooses.
•The player making the cut divides the set into two parts, between which he/she is indifferent. $V_A(X_1) = V_A(X_2) = 0.5$
Case Study
Assume 2 players want to divide a cake fairly.
ver A, P_A, likes vanilla three times as much as chocolate.
ver B, P_B, likes vanilla and chocolate equally.
r A is the divider.
A divides the cake along the
ontal line as shown.
B chooses the piece which
e values more.
X1 X2 C V X3 X4
Table 1
Slice 1 = X1 + X2
Slice 2 = X3 + X4
V_A 0.5 0.5
V_B 0.5 0.5
Case 2
•Player B is the divider.
•Player B divides the cake along the vertical line, into two indifferent pieces, X1 and X2.
•Player A chooses the piece which he/she values more.
X1 X2 C V
Table 2 | Slice 1 = X1 | Slice 2 = X2
V_A | 0.25 | 0.75
V_B | 0.5 | 0.5
Case 3
•This situation will never happen unless there is some outside influence.
•X1 is 50% of the cake.
•X2 is 10% of the cake.
•X3 is 40% of the cake.
Neither player is indifferent between the two slices.
X1 X2 C V X3
Table 3 | Slice 1 = X1+X2 | Slice 2 = X3
V_A | 0.4 | 0.6
V_B | 0.6 | 0.4
Fair Division Properties
PROPORTIONAL
$V_i(X_i) \geq \frac{1}{n}$ for all i
ENVY-FREE
$V_i(X_i) \geq V_i(X_j)$ for all i ar
EQUITABLE
$V_i(X_i) = V_j(X_j)$ for all i and j
PARETO-OPTIMAL
There is no other division that is be for one player and at least as good other players.
Properties of the Divide & Choose Method
PROPORTIONAL (ALWAYS)
Case 1 & Case 2
EQUITABLE (SOMETIMES)
Case 1 & Case 3 (Not Case 2)
ENVY-FREE (ALWAYS)
Case 1 & Case 2
PARETO-OPTIMAL (SOMETIME
Theorem 1: If a fair division
Conclusion

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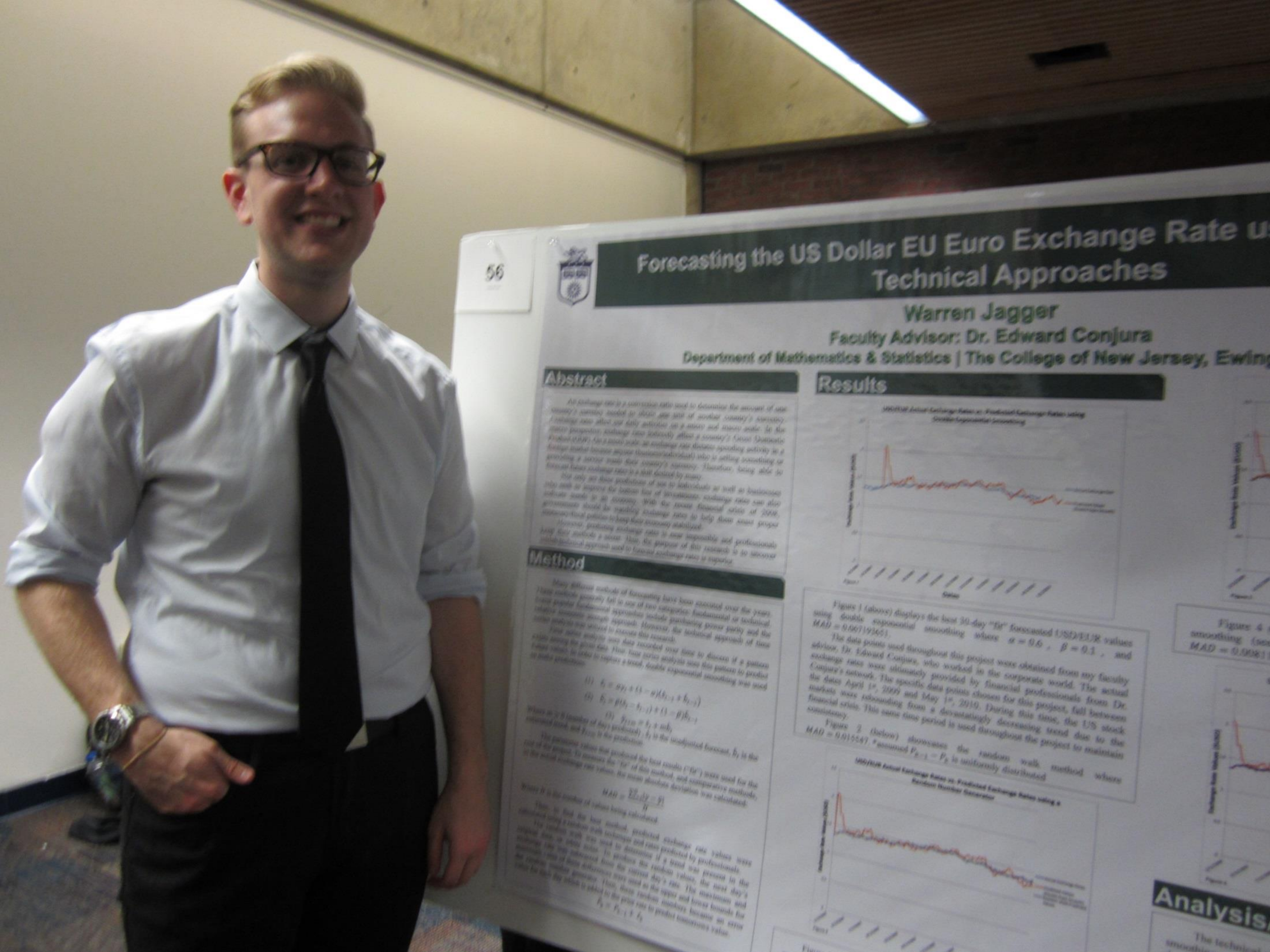
TCNJ
Strategizing the Adjusted Winner Procedure in a Company
Christopher Falk
Dr. Andrew Clifford
Abstract
Example
2. Transfer stage
So far, Sancorp won 40 points. Tech Co won 35. Transfer the tied goods to Tech Co.
Tech Co becomes the Temporary Winner. Analogously, Sancorp becomes the Temporary Loser.
Analysis by Point Ratios
Definition – Tech Co's Point Ratio for a good is Tech Co's valuation of the good divided by Sancorp's valuation.
If Tech Co's point ratio for a good is X, we say, "Tech Co values the good X-times more than Sancorp."
Transfer goods to Sancorp in ascending order of Tech Co's point ratios (lowest PR's → highest PR's)
Sancorp
Tech Co
Company name
Primary location
Chairman
CEO
Immunity to EE layoffs
Totals
3. ★ Equitability adjustment ★
This step is crucial. The equitability adjustment is unique to the AW procedure, and guarantees equitability with absolute certainty.
Equitability means that each player values their allocation exactly equal to the other.
This is often difficult to achieve with fair division schemes.
Solving for p
Definition – p is the percentage of the CEO good Sancorp needs to receive to achieve an equitable allocation.
55+30p=35+30(1-p)
→p = 1/6
Other Con
1. Manipulatio
Highly difficult to unfa
Strong condition must
exact point valuation
your valuations.
Allocation = Envy-free
Effectively, you win m
2. Honesty allo
The optimal outcome
1. Announce
2. Have polar
Consider the following ex
Co. name
Location
Chairman
CEO
EE layoffs
Totals



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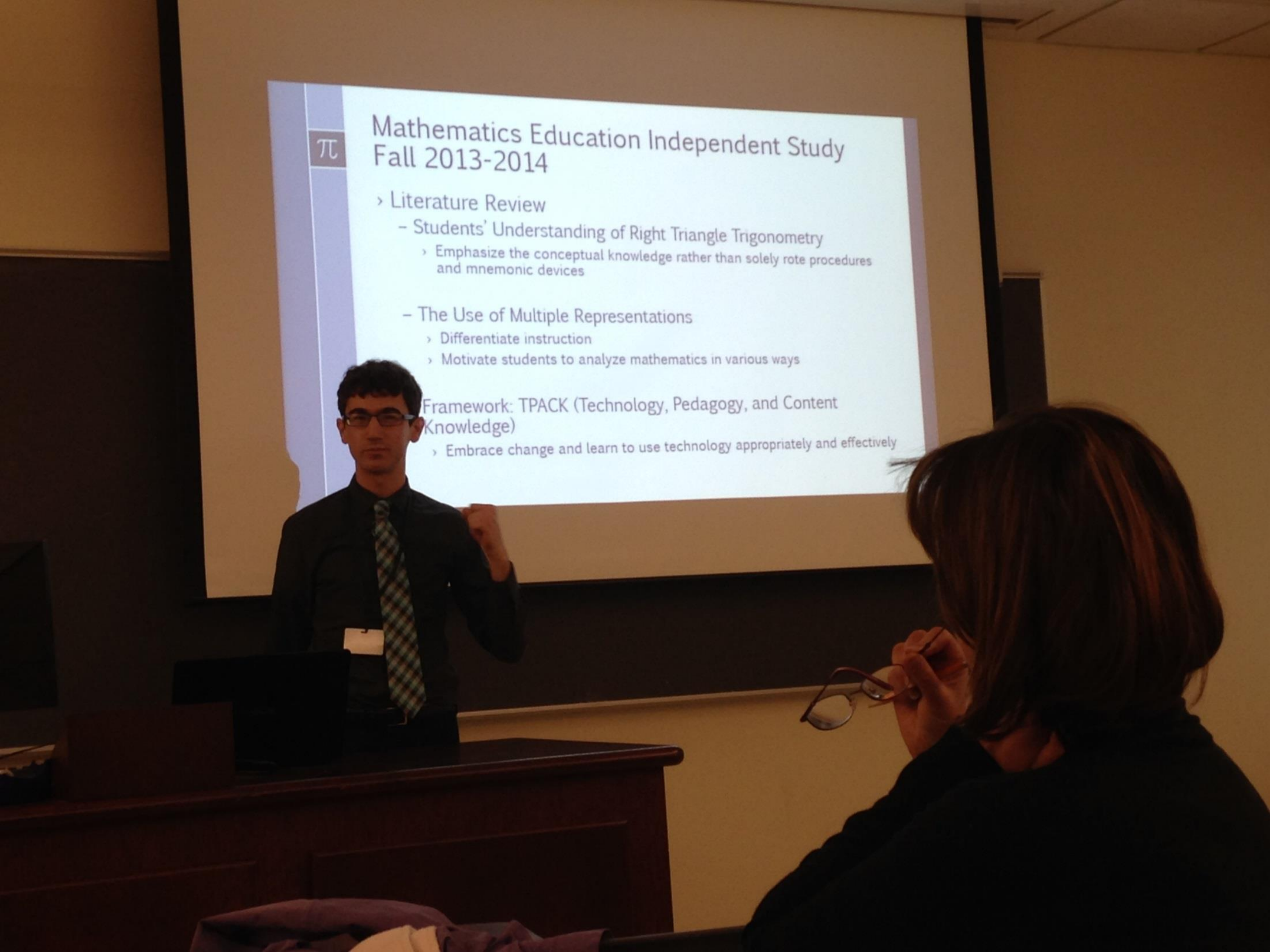
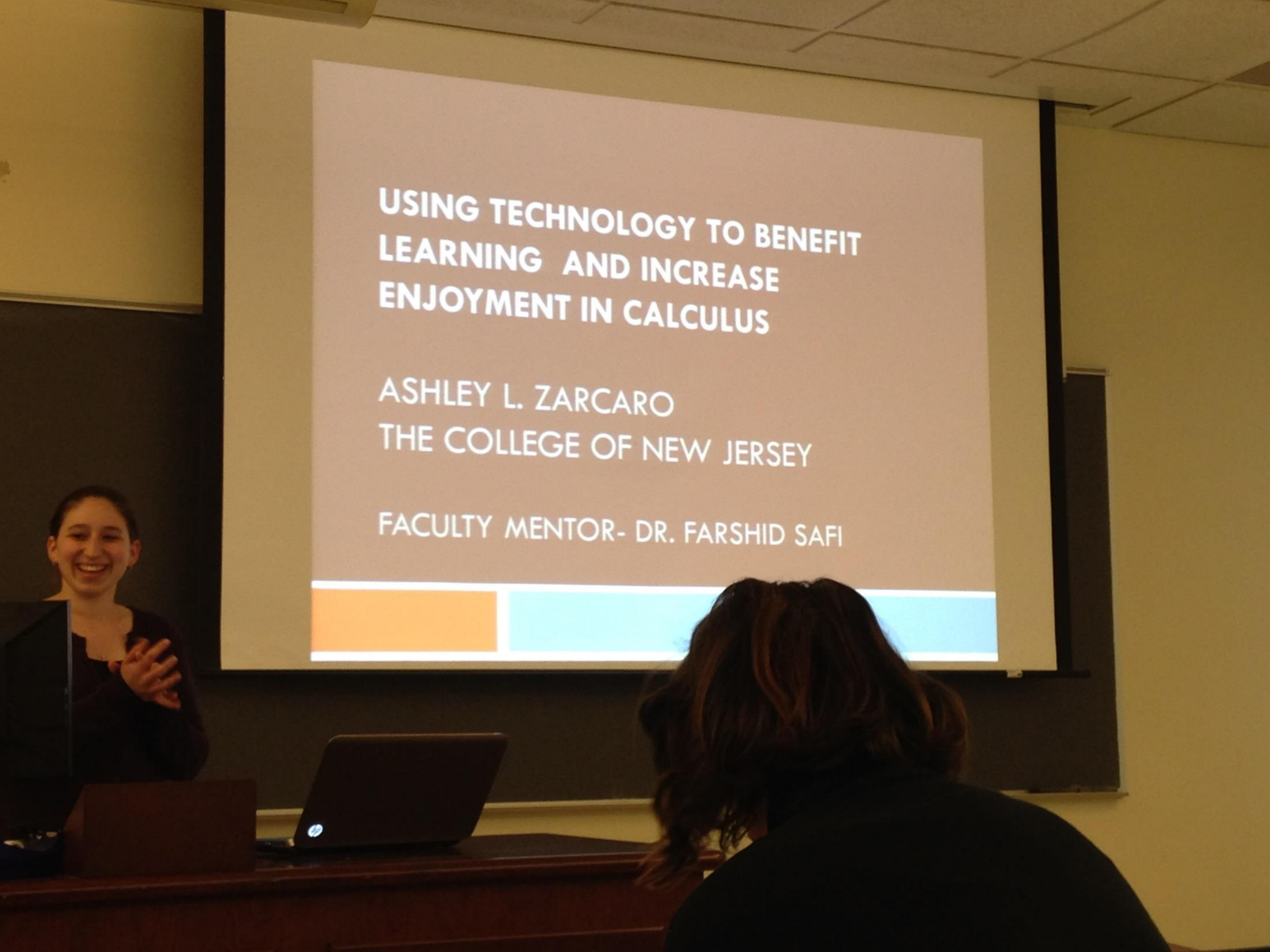
Forecasting the US Dollar EU Euro Exchange Rate
Technical Approaches
Warren Jagger
Faculty Advisor: Dr. Edward Conjura
Department of Mathematics & Statistics | The College of New Jersey
Abstract
Results
Method


Mathematics Education Independent Study Fall 2013-2014
› Literature Review
– Students' Understanding of Right Triangle Trigonometry
› Emphasize the conceptual knowledge rather than solely rote procedures and mnemonic devices
– The Use of Multiple Representations
› Differentiate instruction
› Motivate students to analyze mathematics in various ways
Framework: TPACK (Technology, Pedagogy, and Content Knowledge)
› Embrace change and learn to use technology appropriately and effectively


USING TECHNOLOGY TO BENEFIT LEARNING AND INCREASE ENJOYMENT IN CALCULUS
ASHLEY L. ZARCARO
THE COLLEGE OF NEW JERSEY
FACULTY MENTOR- DR. FARSHID SAFI


Reynolds Middle School Hamilton, New
REYNOLDS
RAIDERS
LOCATION
POPULATION
INVOLVEMENT
TECHNOLOGY


File Edit View Favorites Tools Help
Suggested Sites Web Slice Gallery
Page Safety Tools
Some examples from my student teaching:
Algebra II: The class as a whole would determine how to find formulas for finding terms and sums of arithmetic and geometric sequences and series. The Honors students would always ask where these formulas came from, so this satisfied their curiosity.
Math Analysis: Verifying trigonometric identities requires a lot of proof based skills. Students struggled with these skills, so I tried to give them some pointers when we worked on these problems.
VERIFYING TRIGONOMETRIC IDENTITIES
Scribd


REFLECTION
Jerry
Graphic organizers really helped recall information.
Showed some improvement in his communication of his mathematical reasoning.
Discussions did not help as much since he was not always focused.
Most likely will not continue to improve.
Melissa
Discussions helped improve her confidence.
Improved more than Jerry in her communication of her mathematical reasoning.
She really like the graphic organizers. Helped her study.
May continue to improve.
RECOMMANDATIONS


R's Assessment 1:
-Did not answer any questions
-When asked after class, he replied "I didn't understand what to do"
Law of Sines/Cosines Word Problems


EPSON


EPSON


Learning Goals
Understand the importance and benefits of visualization
Comprehension of a problem statement
First strategy: 1- Display concepts artistically, 2- Mathematical writing to display conceptual understanding
Second strategy: Complete correctness with or without a picture given to them
Vol (sphere) = 4/3 π r^3
Area (sphere) = 4 π r^2
Vol (cylinder) = π r^2 h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Student Statement
Megan
John