IRSTI 83.03.02, 83.03.33, 83.77.31 https://doi.org/10.26577/HJ.2020.v56.i2.07

A.B. Alzhanova , Y.M. Sajjad , A.Anarbek , G.S. Seraliyeva

Al-Farabi Kazakh National University, Kazakhstan, Almaty,
e-mail: aljanova.aigerim@gmail.com; e-mail: sajjadyasa@live.com;
e-mail: adina.anarbek@gmail.com; e-mail: seraliyeva.gulden@gmail.com

USAGE OF STATISTICS IN STUDENT RESEARCH WORK

The relevance of the topic is due to the demand for statistical processing of experimental data in the preparation of research work. Students often have difficulty analyzing a large amount of data. However in order to analyze the data for practical purposes, it is not necessary to be fluent in mathematical formulas, probability theory, or mathematical analysis. There are various types of programs that can be utilized without in-depth knowledge of the applied mathematics.

The purpose of the article is to present methods of statistical processing of information, the main directions of the use of data in student research papers. The authors of the article introduce the types of research in the field of statistics, give examples for each of them. They consider where the data comes from, how they receive the data, what they look for in the data, how to process the data, and how best to work with the results. The main direction of scientific research is a description of skills, the process of building a model, the applied software and algorithmic tools, the possibility of using various statistical data processing programs.

The research methodology is based on the concepts of domestic and foreign researchers, who have a scientific platform, based on the principles of objectivity, concreteness. The value of this work is that students will learn to use these statistical methods in their research, develop a research methodology, process and interpret data, and correctly use the results.

Key words: statistical method, data processing, statistical research; student studies; statistical data processing.

А.Б. Альжанова, Я.М. Саджад, А. Анарбек, Г.С. Сералиева

Әл-Фараби атындағы Қазақ ұлттық университеті, Қазақстан, Алматы қ.,
e-mail: aljanova.aigerim@gmail.com, e-mail: sajjadyasa@live.com;
e-mail: adina.anarbek@gmail.com, e-mail: seraliyeva.gulden@gmail.com

Студенттердің зерттеу жұмысында статистика әдісін қолдануы

Тақырыптың өзектілігі ғылыми-зерттеу жұмыстарын дайындауда тәжірибелік мәліметтерді статистикалық өңдеуге деген сұранысқа байланысты. Студенттер көбінесе үлкен көлемді деректерді талдауда қиындық көреді. Бірақ деректерді практикалық мақсатта талдау үшін математикалық формулаларды, ықтималдықтар теориясын немесе математикалық анализді еркін меңгерудің қажеті жоқ. Жұмыс кезінде қолданылатын математиканың мәніне терең үңілмей-ақ қолдануға болатын түрлі бағдарламалар бар.

Мақаланың мақсаты – ақпаратты статистикалық өңдеу әдістерін, студенттердің ғылыми жұмыстарында мәліметтерді қолданудың негізгі бағыттарын ұсыну. Мақала авторлары статистика саласындағы зерттеулердің түрлерін ұсынады, олардың әрқайсысына мысалдар келтіреді. Олар деректердің қайдан алынғанын, оларды қалай қабылдайтынын, деректерді қалай іздейтінін, деректерді қалай өңдеуді және нәтижелермен қалай дұрыс жұмыс істеуді қарастырады. Ғылыми зерттеудің негізгі бағыты – дағдыларды сипаттау, үлгіні құру процесі, қолданбалы бағдарламалық жасақтама және алгоритмдік құралдар, мәліметтерді өңдеудің әртүрлі бағдарламаларын қолдану мүмкіндігі.

Зерттеу әдістемесі ғылыми платформасы бар, объективтілік, нақтылық принциптеріне негізделген отандық және шетелдік зерттеушілердің тұжырымдамаларына негізделген. Бұл жұмыстың құндылығы студенттердің зерттеу барысында осы статистикалық әдістерді қолдануды, зерттеу әдістемесін жасауды, деректерді өңдеуді және түсіндіруді, нәтижелерді дұрыс пайдалануды үйренеді.

Түйін сөздер: статистикалық әдіс, мәліметтерді өңдеу, статистикалық зерттеулер, студенттік оқу, статистикалық мәліметтерді өңдеу.

А.Б. Альжанова, Я.М. Саджад, А.Анарбек, Г.С. Сералиева
Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы,
e-mail: aljanova.aigerim@gmail.com, e-mail: sajjadyasa@live.com;
e-mail: adina.anarbek@gmail.com, e-mail: seraliyeva.gulden@gmail.com

Метод статистики в исследованиях студентов

Актуальность темы обусловлена востребованностью статистической обработки экспериментальных данных при подготовке научно-исследовательской работы. Студенты часто испытывают трудности при анализе большого массива данных. Но для того, чтобы анализировать данные в практических целях, не обязательно свободно владеть математическими формулами, теорией вероятностей или же математическим анализом. Есть различные программы, которые можно применять, глубоко не вникая в сущность используемой там математики.

Цель статьи – представить способы статистической обработки информации, основные направления использования данных в студенческих исследовательских работах. Авторы статьи знакомят с типами исследований в области статистики, приводят примеры по каждому из них. Рассматривают, откуда берутся статистические сведения, как получают данные, что ищут и как нужно обрабатывать данные, как лучше работать с полученными результатами. Основное направление научного исследования – описание навыков, процесса построения модели, применяемых программных и алгоритмических средств, возможности использования различных программ статистической обработки данных.

Методология исследования строится на концепциях отечественных и зарубежных исследователей, которые имеют под собой научную платформу, основаны на принципах объективности, конкретности. Ценность данной работы в том, что результаты исследования могут быть использованы при обучении студентов методам статистики, методологии научных исследований, умениям обрабатывать и интерпретировать данные, корректно использовать полученные результаты.

Ключевые слова: метод статистики, обработка данных, статистические исследования, студенческие исследования, статистическая обработка данных.

Introduction

The use of statistics in a scientific way is entirely modern. Although that all policy maker knew about the role of statistics in policy of goverenmnets, in ancient times there were counts of people, but no scientific study made of the results. As statistics and data studies are understood as a group of facts relating to a part or whole of a country or society, every country has an organization for statistics and data researchs of country. In Afghanistan, this organization is known as National Statistic and Information Authority, which works to create a single scientific data registration system. National Statistics and Information Authority, formerly known as the Central Statistics Organization, was established in 1972 as an independent authority within the government of Afghanistan in order to establish a coordination mechanism for managing statistical information within all sectors in the country. Through 1973-1978, NSIA extended establishing offices in other provinces of the country. In 1991, NSIA was promoted from Central Statistics Organization to a ministry. However, this lasted only for one year.

Students programs for statistics and related majors often contain opportunities for students to improve skills and experience in the practice of statistics beyond their regular course work. Examples from organizations with student's statistics programs take in research courses (Yesilcay 2000), capstone courses (Spurrier 2001), consulting courses (Villagarcía 1998; Boomer, Rogness, and Jersky 2007), and consulting centers (Legler et al. 2012). Each of these examples offers students with opportunities to apply what they have learned from statistics and to develop communication and other skills needed for success as a statistician. At issue, however, is how statistics and socieial science faculty without a statistics major or minor or a consulting center can provide related experiences for their students, to employ them in the practice of statistics. Some statistics and socieal science faculty have the opportunities for mathematics and general education students to occupy in the practice of statistics. For example, one of the consulting courses described by Boomer, Rogness, and Jersky (2007) is open to students who are not majoring in mathematics but who have completed an introductory statistics course. A data analysis course (Schafer and Ramsey, 2003) can also provide statistics majors and non-majors alike with practice in statistics skills beyond an introductory course. However, for statistics and social

science faculty teaching in departments where consulting or data analysis courses are not available, supervising students research projects can provide opportunities to expose students to the biger array of works associated with the practice of statistics. In this article the main is to engage students to the statistics discipline. Will combine a summary of the skills students need to be effective statistical practitioners, as well as recommendations for statistics and social science faculty interested in supervising students research projects and a summary of the overall benefits of student's research.

Material and methods.

The reaserch methodology of this article is qualitative library based study. Informations and data are togetherd from prestigious research articles with case study reaserch. This article contains examples, applied projects and practical informations, which obtained from newst articls.

Literature review. Increasingly, researchers, theorists, and practitioners emphasize learning as a social phenomenon (Lave & Wenger, 1991; McGinn, 2009; Packer & Goicoechea, 2000; Salomon & Perkins, 1998). People interact and learn in social settings, and part of what they learn is social content. Even when individuals work or study independently, they interrelate with books and tools that are socially located. To know better, it is therefore necessary to pay on the social milieu for that learning, which contains considering who learners are, whom they interrelate with, and what learners and others do. Social learning theories also draw attention to the relationship between the social milieu where learning is developed and the social milieu where learners are expected to apply that learning. This focus leads some scholars and practitioners to advocate for "authentic learning" where the setting for initial learning is designed to resemble the settings for desired application (Herrington & Herrington, 2006; Rule, 2006). Salomon and Perkins (1998) provide an inclusive review of a multitude of theoretical and empirical investigations of the ways that learning is social. For this study, I assume their typology to describe learning opportunities for statistical works.

Questions of research

What is the role of statistics in research?

How do we use statistics in research?

What are the types of statistics?

How are statistics important?

What is the relationship between statistics and research?

Statistical analysis and statistical thinking involve much more than manipulating numbers using set formulas (Reid & Petocz, 2002; Wild & Pfannkuch, 1999). Producing, composing, applying, using, understanding, or communicating statistics requires tacit knowledge, heuristics, communication skills, and a facility to capitalize on the social situation. Gephart (1988) coined the label "ethno statistics" to refer to community-specific approaches that shape the use of statistical methods in research. The field of ethno statistics involves the "empirical study of how professional scholars construct and use statistics and numerals in scholarly research" (Gephart, 2006, p. 417). Gephart (1988, 2006) delineated three general areas of scholarship within ethno statistics: (a) ethnographic studies of groups who produce statistics (e.g., Latour & Woolgar, 1986; Lynch, 1985), (b) analyses of the technical and practical assumptions involved in producing statistics (e.g., Cohen, 1994; Lieberson, 1985), and (c) analyses of the use of statistics as rhetorical or persuasive devices in research publications (e.g., McCloskey, 1985; Roth, Bowen, & McGinn, 1999). All three areas of scholarship reveal that contingent practices and artful decision making are ubiquitous in statistical analysis. Findings drawn from the field of ethno statistics stand in stark contrast to mainstream beliefs about the perceived objectivity and precision of statistical methods. Many novice's statistics users seem to believe that statistical methods of data analysis proceed in strictly methodical fashion whereby the researcher uses a pattern recognition strategy to select data analysis methods that match the research question and accumulated data. This myth suggests that once the researcher has selected the "correct" strategy, it is a simple matter of following the corresponding steps to complete the analysis, and the results of this analysis are then slotted into a research report template. Experienced statistics users know that researchers are not constrained in this way, yet the myth persists, leading statistics educators to question how to support students to develop more accurate and robust conceptions of statistics (Reid & Petocz, 2002).

Results and discussion.

In describing their research, consulting and other courses or programs, several authors have showed what features of statistical practice their programs payed on. (Legler et al 2012) provided examples of how their consulting center encounters recommendations to train students in the practice of statistics that were established forth by the American Statistical Association›s Students Statistics

Education Initiative (USEI). The consulting center develops statistics skills in these five catagorys:

statistical skills
mathematical skills
nonmathematical skills
computing skills
substantive area skills

Toward developing students' skills, Spurrier's (2001) capstone course includes a series of eleven statistical methods-based practices augmented by other modules to develop students' communication and consulting skills. Since the projects differ each time a research project course is offered, the skills described by (Yesilcay 2000) are project dependent. Though, they typically include choosing a suitable statistical model, data collection and analysis, and interpretation of results. (Boomer, Rogness, and Jersky 2007) and (Legler et al. 2012) defined a similar reliance on the flexibility of statistical content required for a successful consulting experience for their students. (Das 2013) included some examples of exact mathematics skills and functional area skills (e.g., background knowledge of actuarial mathematics) that were required by students to complete their students research projects. However, each of these experiences develops students' skills in various ways, they share a common theme of working to answer a real problem. The components of statistical practice were improved by (Pfannkuch and Wild 2000) in an article summarizing a series of interviews with professional statisticians on their working experiences. The PPDAC (Problem, Plan, Data, Analysis, Conclusions) framework apllyed in this article to define these statisticians' understandings offers an effective structure for conducting students research in statistics.

Although data analysis, modeling, and consulting are a big part of what statisticians do, one statistical activity that is not a part of the student's research experiences described above is the enlargement and/or assessment of new or improved statistical methods. The students research projects that have been mentored often offer students with this experience. Though this approach to dealing with multicollinearity may not be a practical option, the student learned about the effectiveness of remedial measures for multicollinearity and about the importance of designing a suitable data collection protocol. A student compared numerous methods for determining the number and type of parameters needed for fitting a time-series model to a collection of simultaneous datasets consisting of Twitter "tweets" from cities across the United States. Hence, two other students created a modified form of Fleiss's kappa for situations where raters made more than one rating on the same set of objects. They then assessed the usefulness of their kappa measurement on a dataset with nine dissimilar rating criteria and compared the results to using Fleiss's kappa on the nine ratings individually. Each of these research projects involved developing a new method or measure and then conducting simulations to evaluate their way or measure and to compare it to existing methods.

Related to the program described by Legler et al. (2012), we try to provide research opportunities that appeal to and are accessible to mathematics majors. Students research projects that emphasize mathematical derivations and simulations, rather than data analysis and statistical applications alone, are reachable even to mathematics students with limited exposure to statistical methods and statistical thinking. The fact that the discipline of statistics combines a wide variation of activities and skills, from theoretical and mathematical results to applications and computational methods, is what that we try to demonstrate to research students with each project. These projects can contain some original work toward filling a gap in statistical knowledge, but that has not always been a must for my projects, contrary to the recommendations of (Das 2013) and some definitions of student's research (e.g., Roberts 2013). Furthermore, there is facility for student's research projects in statistics to provide students with substantive content area skills, mostly through interdisciplinary collaborations. Examples contain mathematical modeling (McMillan and Lickley 2008), biological systems (Diaz et al. 2009, and Friedman-Gerlicz 2009), environmental data (Carlson and Ecker 2002), physical properties (Senko 2010), and social structures (Egesdal et al. 2010). In each of these examples, substantial knowledge of the discipline underlying the data or system is essential for students to place their results in the fitting context.

Benefits of Students Research

Students research is one type of active learning and much has been mentioned on its benefits as used across many disciplines (see, e.g., Russell et al. 2007, Petrella and Jung 2008, and Lopatto, 2010). Within the mathematical sciences and statistics disciplines a number of of the authors cited in this article offer some discipline-specific and other benefits. (Yesilcay 2000) prepared a summary of benefits for students, from problematic description and model selection to increasing students' capacity for independent study, teamwork, and leadership skills, as well as potential employment opportunities for students. (Das 2013) described the progress of links between students and the mathematics

community resulting from contributing in student's research and the importance of academic year research projects for faculty which are not linked with a summer research program. (Roberts 2013) included the supplementary benefit for faculty engaged in student's research of providing a break from other academic responsibilities. For many faculty mentoring students research offers an opportunity to progress their research and/or work with statistical methods and tools that are not part of the classes they teach. Students research is also a suitable way for faculty to share their likes on learning and their interest for discovering something new. Like the impacts described by (Legler et al 2012), most of the students shoed interest on to do an honors project based on their research. All but two succeed on to a graduate program in mathematics or statistics, with several earning a Ph.D. in statistics. Students research in statistics, like data analysis and consulting projects, has the possibility to provide students with training in "the full range of skills required for successful application of statistics" and to determine to students "what is exciting about the field of applied statistics" (Schafer and Ramsey 2003). If conducted as part of a research or consulting course, students can also use their students research practice to meet a major or minor requirement, belongs on the requirements at their institution. Many institution includes an experiential learning requirement as part of general education program and several students use their students research skill to meet this condition. While some disagreement appears, among the authors cited here about the degree to which a students' research project in statistics must contain original work to fill a gap in knowledge, all agrees with the "ultimate goal" of students research for students as stated by Roberts (2013), "to improve their educational experience and to progress their interest in scholarly work."

Students Research in Statistics

Besides to promoting the USEI guidelines, (Legler et al. 2012) also highlighted the experiential learning aspects of student research and the significance of promoting interdisciplinary projects to get ready students for working as part of a team of scientists. They also provided a timeline for research activities, starting with literature review and data analyzing and ending with poster presentations and a research log. (Delzell 2012) defined a phase structure for conducting research with students (data acquisition, visualization, analyses, and communication). She also provided cooperative hints, potential pitfalls, and marginal applications based on her experiences. The PPDAC framework used to define statisticians' experiences in (Pfannkuch and Wild 2000) also provided an importent structure for conducting student research in statistics. (Das 2013) suggested six steps for conducing students research: (1) discover a gap in knowledge, (2) literature search, (3) analysis of the problem (brainstorming), (4) develop method, (5) perform study, and (6) peer review.

Numerous researchers have provided guidance on increasing and mentoring students' research, either in mathematics or in statistics. (Roberts 2013) defined issues with the associated problems of selecting good students' and finding a suitable problem. He provides sequences of questions to pay attention when selecting students' and approaches to developing research projects. Yesilcay (2000) deliberated the major work and activities required to find projects and prepare students for conducting research. Project progress starts during the previous academic year by making interaction with government offices and other sources for information. Preceding to the academic year research project, students' could join in a voluntary summer "apprenticeship in statistics" with the agency they will be working to become acquainted with the agency and the research problem.

Types of Students Research Projects in Statistics

A study of student's research projects in statistics from numerous sources exposed five different types of projects based on the types of activities students carried out. (Sources that were used include Yesilcay (2000), a list of Students Senior Statistics Abstracts from Robin Lock's site at St. Lawrence University http://it.stlawu.edu/rlock/ussa/, theSIAM Students Research Online journal http://www.siam.org/students/siuro/, the American Journal of Students Research http://www.ajur.uni.edu/, The College of New Jersey Journal of Student Scholarship https://joss.pages.tcnj.edu/, and the Pi Mu Epsilon Journal http://www.pme-math.org/.) The titles and abstracts of the projects available at these sources were studied for statistical content and focus. Articles recognized through this method were accessed and reviewed to classify project goals and methods used. Projects were categorized according to similar student knowledge and project results. Projects that displayed characteristics of multiple project types were further studied to identify the main purpose or goal of the project. The five-project types are defined below, each with a short description of two or more representative projects.

Data Analysis Projects

The main goal for this type of project is to apply a statistical model or method, like regression analy-

sis, to existing data regarding to answer a research question by creating summary statistics or providing parameter estimates. E. g, for an environmental studies project (Carlson and Ecker 2002) students' operated with a team of scientists and statisticians to measure changes in water quality in two lakes. A variety of water quality variables were examined (e.g., phosphorous, dissolved oxygen, and turbidity) using discriminant analysis and Analysis of Covariance (ANCOVA) to compare the two lakes and to determine if the lakes had changed from 1999 to 2000. The project described by Delzell (2012) where students' analyzed African war and temperature data is another good example of this kind of project. Two other examples include the use of statistical methods to test for compliance to Benford's law (Pike 2008) and the use of quantile regression and time series to analyze temperature changes over time (Leider 2012). Finally, Cooper, Kirksey, and Diaz (2015) defined the use of regression analysis to evaluate the use of an algebra diagnostic test as a predictor for success in a preliminary statistics course.

Observational Research Projects

For these projects, students plan a survey and data mining procedure that they carry out with the goal of answering an exact research question using data analysis methods. Alternatively, the data can be mined observationally following a specified convention. For example, students planned and implemented a survey to find out the relationships between work-related attitudes, health and coping, and family issues among male and female managers and nonmanagers in a large manufacturing organization (Apperson et al. 2002). In another example, Senko (2010) defined an observational study to assess the necessities of hard of hearing students' and to determine best practices for meeting those needs. The student conducted site visits at three different elementary schools and then used grounded theory analytic approach (Glaser and Strauss 1967) to analyze her field notes and make recommendations of significant factors for defining academic placement for hard of hearing children.

Experimental Research Projects

These projects are more like survey research projects but students plan an experiment to collect data to analyze rather than using a survey or observational protocol. (Hubers et al. 2003) defined an investigational study to examine how participant motivation and experience through the experiment effects participants' compliance in completing a meaningless task. Using a factorial design, the students studied how motivation, required vs. voluntary contribution, and being treated as a data producer vs. a coinvestigator impacted participants' completion of the task. In another example project, students compared an agent-based model with a self-exciting point method to model gang movement (Egesdal et al. 2010). Both models were compared by using a histogram analysis and the Akaike information criterion. As an example a study to examine the impact of fat content in diet on health problems in mice (Diaz et al. 2009) and a comparison of teaching scores between contributors in a professional development program and a control group of teachers (Campanelli and Dougherty 2010). Experimental projects can also be advanced for students with a mathematics or engineering background. like, León-Cázares and Xoconostle-Luna (2014) described an experimental project to evaluate the accuracy of a model of an electric vehicle. The students' compared simulated racing data with experimental results.

Statistical Methods Projects

These projects differ from those focused on data analysis in that students work on the development and evaluation of a new statistical method, or make comparisons between a new method and established, traditional methods of analysis. For example, students may derive properties of new methods mathematically or discover them through simulations and applications. In Grimmer (2005) the student proposed a model to explain voting behaviors and compared this model to ones found through a literature review. Additional examples include the development of error bounds for hypergeometric probabilities (Jalal 2001), a new visualization of Fisher's iris dataset (Benson-Putnins et al. 2011), and a comparison of different methods for generating a phylogenetic tree (Leung 2012). In addition, several projects involving statistical methods that I have conducted were described above.

Probability Projects

The main goal of these projects is to find answers for questions involving the probability of some event or to make predictions using a probability model. Students might derive a possibility distribution or use a known probability distribution in a new setting, then produce approximations and predictions using the distribution or through simulations. Examples include a study of the misclassification rates of hypertension (Friedman-Gerlicz and Lilly 2009) and the use of different random number generators for Monte Carlo simulations in mathematical finance (Pita-Juarez and Melanson 2011). The consulting project described by Villagarcía (1998) also fits in this category. For this project, engineering students conducted simulations to model the probability that power stations will be down and then used their results to simulate the

power supply. Two projects that has been studied involved simulations to evaluate a probability. For the first project, the student ran simulations to evaluate the probability of one item on the top seven items in each of three lists of 30 ordered items. For the second project, the student investigated the probability which fewer than two women would be employed in seven independent job searches using Bernoulli random variables. In each case, the students ran the simulations and then derived the corresponding probability distribution.

Conclusion

An overview of the example projects mentioned here determines the dissimilar ways that students research can contribute to the development of the skills students need for the practice of statistics. Each of these projects contains experience in one or more of the USEI skills listed in Section 2. Many of the projects mentioned above involved data and modeling in other disciplines, like, environmental science, psychology, education, and biology, which need the development of substantive area skills for analyzing data and interpreting the results. Furthermore, to a range of different statistical methods, some of the projects also required substantial mathematical skills, such as engineering and actuarial mathematics. Besides software used for data analysis, many of the projects also needs computing skills to conduct simulations and develop data visualizations. This study also suggests the position of establishing relations with faculty in other disciplines where statistical methods are a significant part of students' preparation, for generating project topics and creating interdisciplinary partnerships.

The projects listed above also demonstrates the wide array of sources for project data and mathematical and other topics where statistical methods are fitting. With some thought and preparation, it should be possible to design a student research project in statistics to link the needs and interests of faculty and students, and to uphold student interest in statistics as a career or graduate school option. Interested faculty may start by considering which courses they teach that might lead to potential interesting projects as well as to students with interest in and appropriate background for those projects. They might also pay on how to structure the project and what research activities students can successfully do within the time allotted for the research project. If a consulting, capstone, or other regular course offering are not a possibility, faculty can investigate offering students research opportunities over a directed study or similar course format.

For statistics and social science faculty teaching at institutions without a major or minor program in statistics, it can be problematic to provide interested students with experience in all of the components of effective statistical practice by existing statistics courses. Students research is suitable way to fill gaps in students' preparation for employment as a statistician or for graduate school in statistics. Moreover, to growing up students' exposure to the practice of statistics, participation in student's research has other assistances for both students and their faculty mentors. The goals of this article were to encourage statistics instructors to consider developing and mentoring students research articles and to provide a summary of the diverse kinds of possible projects.

References

Apperson, M., Schmidt, H., Moore A., Grunbert, L., (2002), "Women Managers and the Experience of Work-Family Conflict," Americ an Journal of Undergraduate Research [online], 1. Available at http://www. ajur.uni.edu/v1no3/ Apperson.pdf

Benson-Putnins, D., Bonfardin M., Magnoni M., Martin D. (2011), "Spectral Clustering and Visualization: A Novel Clustering of Fisher's Iris Data Set," SIAM Undergraduate Research Online, 4. Available at https://www.si am.org/students/siuro/vol4/S01075. pdf [Crossref]

Boomer, K. B., Rogness, N. Jersky, B. (2007), "Statistical Consulting Courses for Undergraduates: Fortune or Folly?" Journal of Statistics Education

Campanelli, J., Dougherty, K. (2010) "The Effects of Sustained Professional Development on Middle School Mathematics Teachers in Urban Schools," TCNJ Journal of Student Scholarship [online], 12. Available at http://joss.p ages.tcnj.edu/ files/2012/04/2010-Dougherty- and-Campanelli.pdf

Carlson E., Ecker M. D. (2002) "A Statistical Examination of Water Quality in Two Iow a Lakes," American Journal of Undergraduate Research [online], 1. Available at http://www. ajur.uni.edu/Carlson_Ecker.pdf

Cooper A., Kirksey J. and Diaz R. E. (2015) "Can an Algebraic Diagnostic Test be Used to Predict Final Grades in an Introductory Statistics Course?,"American Journal of Undergraduate Research [online], 12. Available at http://www. ajuronline.org/uplo ads/ Volume%2012/Issue_2/ AJURVol12Issue2J an2015pp43_56.pdf

Das K. (2013), "From Inquiry-Based Learning to Student Research in an Undergraduate Mathematics Program," PRIMUS, 23, 829–836.

Delzell D.A.P. (2012), "African Conflict and Climate Data for an Undergraduate Research Project," Journal of Statistics Education, 20. Available at http://www.amst at.org/public ations/jse/v20n3/delzell.pdf

Díaz P., Gillespie M., Krueger, J., Pérez, J., Radebaugh A., Shearman T., Vo G., and Wheatley C. (2009), " A Mathematical Model of the Immune System's Role in Obesity-Related Chronic Inflammation," SIAM Undergraduate Research Online, 2. Available at https://www.si am.org/students/siuro/vol2issue2/S01032.pdf [Crossref]

Egesdal M., Fathauer C., Louie K., and Neuman J. (2010), "Statistical and Stochastic Modeling of Gang Rivalries in Los Angeles," SIAM Undergraduate Research Online, 3. Available at https://www.si am.org/students/siuro/vol3/S01045.pdf

Friedm an-Gerlicz, C., and Lilly, I. (2009), "Misclassification Rates in Hypertension Diagnosis due to Measurement Errors," SIAM Undergraduate Research Online, 2. Available at https://www.siam.org/students/siuro/vol2issue2/S01031.pdf [Crossref]

Glaser B. G., and Strauss, A.L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. New York, NY: Aldine Transaction.

Grimmer J., (2005), "Aw areness, Partisanship and the Post-Convention Bounce: A Memory-Based Model of Post-Convention Presidential Candidate Evaluations: Part II – Empirical Results," American Journal of Undergraduate Research [online], 3. Available at http://www. ajur.uni.edu/v3n3/Grimmer%20pp%2015-24%20rev.pdf

Hubers K. J., Graf E. R. and Lantinga S. B. (2003), "The Influence of Meta-Experiment al Factors on Compliance and Attitudes: Particip ant Motivation and Experimenter Demeanor," American Journ al of Undergr adu ate Rese arch [online] 2. Av ail able at http://citeseerx.ist.psu.edu/viewdoc/downlo ad?doi=10.1.1.518.3777&rep=rep1&type=pdf

Jalal A. I. M. (2001), "Error Bounds Involving Almost-Binomial Approximations of Hypergeometric Probabilities," Pi Mu Epsilon Journal, 11, 187–193.

Legler, J., Roback, P., Ziegler-Graham, K., Scott, J., Lane-Getaz S., and Richey, M. (2012), "A Model for an Interdisciplin ary Undergraduate Research Program," The American Statistician, 64, 59–69. [Taylor & Francis Online], [Web of Science ®]

Leider, J. (2012) "A Quantile Regression Study of Climate Change in Chicago, 1960-2010," SI AM Undergraduate Research Online, 5. Available at https://www.si am.org/students/siuro/vol5/S01174.pdf [Crossref]

León-Cázares F. D., and Xoconostle-Luna D. (2014), " A Student Approach to a Mathematical Simulation of a Racing Electric Vehicle," American Journal of Undergraduate Research [online], 12. Available at http://www. ajuronline.org/uplo ads/Volume%20 12/Issue_1/ AJURVol12Issue1 Aug2014pp20to26.pdf

Leung C. (2012), "Bayesian Models for Phylogenetic Trees," McGill Science Undergraduate Research Journal, 17. Available at http://msurj.mcgill.c a/vol7/iss1/Leung2012.pdf

Lopatto D. (2010), "Undergraduate Research as a High-Impact Student Experience," Peer Review, 12. Available at https://www. aacu.org/publications-research/periodicals/undergraduate-research-high-impact-student-experience

McMillan J., and Lickley, M. J. (2008), "The Potential of Tidal Power From the Bay of Fundy," SIAM Undergr adu ate Rese arch Online 1. Available at https://www.siam.org/students/siuro/vol1issue1/S01006.pdf [Crossref]

Petrella J. K., and Jung A. P. (2008), "Undergraduate Research: Importance, Benefits, and Challenges," International Journal of Exercise Science 1, 91–95. Available at http://digitalcommons.wku.edu/cgi/viewcontent.cgi? article=1036&context=ijes [PubMed]

Pf annkuch, M., and Wild, C. J. (2000), "Statistical Thinking and Statistical Practice: Themes Gleaned from Profession al Statisticians," Statistical Science, 15, 132–152. [Web of Science ®]

Pike D. P. (2008), "Testing for the Benford Property," SI AM Undergraduate Research Online, 1. Available at https://www.si am.org/students/siuro/vol1issue1/S01009.pdf [Crossref]

Pita-Juarez Y. H., Melanson, S. (2011), "Europe an Option Pricing Using a Combined Inverse Congruential Gener ator," SI AM Undergr adu ate Rese arch Online, 4. Available at https://www.siam.org/students/siuro/vol4/S01077.pdf [Crossref]

Roberts G. E. (2013), "Conducting Mathematical Research with Undergraduates," PRIMUS, 23, 785–797.

Russell S. H., Hancock M. P., and McCullough J. (2007), "Benefits of Undergraduate Research," Science, 27. Available at http://science.sciencem ag.org/content/316/5824/548.full

Schafer D.W., and Ramsey F.L. (2003), "Teaching the Craft of Data Analysis," Journal of Statistics Education [online]

Senko L. (2010), "Addressing the Unique Needs of Hard of Hearing Students in Diverse School Settings," TCNJ Journ al of Student Scholarship [online] 12. Available at http://joss.p ages.tcnj.edu/files/2012/04/2010-Senko.pdf

Spurrier J. D. (2001), " A Capstone Course for Undergraduate Statistics Majors," Journal of Statistics Education [online]

Villagarcía T. (1998), "The Use of Consulting Work to Teach Statistics to Engineering Students," Journal of Statistics Education

Yesilcay Y. (2000), "Research Project in Statistics: Implications of a Case Study for the Undergraduate Statistics Curriculum," Journal of Statistics Education