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**Statistics Instruction to Rural High School Students and
Teachers in Tennessee**

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Statistics Instruction to Rural High School Students and Teachers in Tennessee

ABSTRACT

The United States Department of Education recently awarded a \$9 Million, five-year EIR grant to the Niswonger Foundation of Greeneville, Tennessee, USA ("The Foundation"). In writing its proposal for funding, The Foundation was guided by the concept of *Learning Design (L.D.)*, defined as "the creative and deliberate act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational results....". Indeed, the grant is unfolding using Learning Design as its underlying principle. Readers will be able to find out much more about the Foundation's STEM.LD Project at <https://niswongerfoundation.org/about/stem-ld/>. By partnering with a diverse group of institutions and Agencies, the Foundation has used the subcontract mechanism as its method of realizing its vision. The partners are as follows:

- Biobuilder Educational Foundation, Cambridge, Massachusetts,
- Civil Air Patrol, Maxwell Air Force Base, Alabama,
- East Tennessee State University (ETSU), Johnson City, Tennessee,
- Hammer Math, Franklin, Tennessee,
- Northeast State Community College (NSCC), Blountville, Tennessee,
- Purdue University, West Lafayette, Indiana
- Streamworks Education, Kingsport, Tennessee,
- The New Teachers Project (TNTP), New York, New York,
- The University of Alabama in Huntsville (UAH),
- Walters State Community College (WSCC), Morristown, Tennessee.

See also ETSU's webpage at https://www.etsu.edu/coe/stem-education/niswonger_stem_ld.php where we talk about our Professional Development and courses in Epidemiology, Biostatistics, Artificial Intelligence, Machine Learning, and Statistics with Technology, which is the prime focus of this article.

The Grant and the Location

The grant activities are based in Rural Northeast Tennessee, east of the Knoxville region where ATINER's Prof. Timothy Young's University of Tennessee is located. Students in the region have generally had limited opportunities, and limited advanced coursework. The STEM.LD project aims to revert this situation, working with several dozen middle and high schools, using a controlled experimental design over 5 years. The STEM.LD Grant, as outlined by The Foundation, focuses on three components:

- a. Strengthening the teaching and learning classroom experiences with engaging materials for students, combined with the professional development of their teachers,
- b. Experiential out-of-school-time (OST) opportunities to explore the diversity of STEM content, and
- c. Expanding participation in rigorous STEM and dual enrollment classes.

At ETSU, we are focused on a. and c. above. This article describes our efforts in building a dual enrollment Statistics class which will enable students to fulfil the Tennessee Statistics course requirements while, simultaneously, introducing them to open source software such as R. Our numbers are expected to be initially small (in the Fall of 2023, Year 3 of the project) but expected to grow in Years 4 and 5 of the project. Engaging students with real-life data sets, and enabling them to analyze them, will prepare students both for College and Career, and our Statistics course is therefore in the spirit of a STEM course, where we always use the acronym in its 2.0 version, i.e., engaged interdisciplinary and multidisciplinary content that crosses bridges between academic disciplines. Finally, in the area of professional development of teachers, we have offered two workshops for high school teachers that focus on Statistics with R.

The Dual Enrollment Class

In this section, we will provide an overview of one of the two dual enrollment classes to be offered at ETSU in Fall 2023, to students and alumni of STEM.LD partnership schools. The two asynchronous classes will be

- Probability and Statistics, MATH 1530, the content of this article, and
- Mathematical Computing MATH 2090.

MATH 1530, 3 credits, will be taught as an asynchronous section of Probability and Statistics. It will have a few synchronous meetings to facilitate team building and for the graduate assistant to hold office hours. It will run for 15 weeks and be focused on Technology (R and Minitab). Professor John Hicks will be the instructor. MATH 2090 (2 credit) will be focused on Practical

Machine Learning -- another multidisciplinary and contemporary STEM class. Tuition for both classes will be paid.

Logistics and the Textbook

The class will be offered to eligible juniors and seniors (and also ETSU freshmen) primarily from the following STEM-LD Partnership school districts: Cocke County, Hawkins County, Johnson County, Unicoi County, and Washington County, with whom ETSU has active partnerships -- even though we may open the course up to all the STEM.LD schools.

The courses will be taught using a syllabus that may be best described as "Practical Concept-Based Statistics with Technology" which has guided the teaching of MATH 1530 at ETSU since the mid-1990's. Indeed, ETSU was the first school in Tennessee to mandate either Calculus or Statistics as its general education Mathematics course; the latter is taken by close to 2000 students each year. Most other schools, at that time, required College Algebra as their general education Mathematics class.

It is our plan to have the course taught by high school teachers in the future, and embedded into existing required classes such as Algebra 1 and 2 -- so that *all* students will learn programming in context, so as to combat the phenomenon of coding classes being populated entirely by boys.

A text written by the second and third authors of this paper, Ms. Alfaro and Dr. Hicks, will be used as the primary source. This text [1] is titled *Statistics with Technology for High School*, and is indeed one of the key products of the ETSU-Foundation partnership. The course is based on the analysis of data sets, small and large, in the context of key introductory statistical methods such as confidence intervals, descriptive and graphical statistics, hypothesis tests, and regression. It is suitable for all STEM students, whether they are headed towards college or career. Even though there do exist books for Statistics instruction at the high school level, e.g., [2, 3] the present book features

- Strict adherence to the Tennessee Mathematics Standards [4];
- A complete incorporation of Open Source software;
- A focus on key concepts, as in all sections of the MATH 1530 course taken by close to 2000 students each year at ETSU.

To quote from the book,

"This booklet was developed as a part of the STEM.LD project at East Tennessee State University, funded by the Niswonger Foundation. For its elaboration, the authors of this work have drawn upon their extensive knowledge and experience to curate a collection of original explanations, examples and exercises. These materials have been meticulously crafted to illustrate key concepts and provide readers with valuable opportunities for

practice and skill development, built upon the fundamental framework of the Scientific Method, which is at the heart of an introductory course in Probability and Statistics.

By embracing this systematic approach, readers will gain a solid foundation in Probability and Statistics, and the practical application of R will aid in more complex computations and data visualization. The ... work...is not intended to be a comprehensive work on Probability and Statistics, but just an introduction to some of the topics as well as an introduction to using R. R is an open sourced statistical software program that at its core, is a versatile tool functioning as a calculator, in which the inputting of code results in valuable output that aim to aid in complex computations and data visualization. A brief overview of R is found at the end of this booklet, and code excerpts are provided to demonstrate the concepts applications in R.

This booklet serves as just an introduction, by not going into great detail on some topics, but when appropriate, further elaboration is given to gain a better understanding."

It is the view of the first author of this paper, Dr. Anant Godbole, that [1] can be of great benefit so diverse audiences of students, including students needing remediation, English language learners, and other groups.

Foundations

The following conceptual topics from Utts [5] will be incorporated into the course in a fundamental fashion:

1. When can it be concluded that a relationship is one of cause and effect and when it cannot.
2. The difference between statistical significance and practical significance, especially when using large sample sizes.
3. The difference between finding “no effect” or “no difference” and finding no statistically significant effect or difference, especially when using small sample sizes.
4. Common sources of bias in surveys and experiments.
5. The idea of coincidences and seemingly rare events are not uncommon because there are so many possibilities.
6. Conditional probability in one direction is confused with the conditional probability in the other direction.
7. Understanding that variability is natural, and that “normal” is not the same as “average.”

References

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