Affordable Learning Georgia Textbook Transformation Grants

Final Report for Mini-Grants

General Information

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Institution Name(s): Clayton State University

Team Members:

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Project Lead: Dr. Michael J. Dancs

Course Name(s) and Course Numbers: Elementary Statistics (Math 1401)

Final Semester of Project: Spring 2020

1. Project Narrative

Project Description:

WeBWorK (http://webwork.maa.org) is a no-cost and open-source online homework system supported by the Mathematical Association of America and the National Science Foundation, currently used at hundreds of colleges and universities, including several USG institutions. WeBWorK is distributed with a large set of contributed problems (the Open Problem Library) and provides the means for instructors to edit existing problems and create completely new ones.

Although the WeBWorK software is free to use, students sometimes struggle due to a lack of features available on commercial platforms, e.g.: guided solutions, similar examples, and personalized feedback. While WeBWorK does provide a framework for these features, individual problems must be specifically designed

and written to leverage this functionality, and there are very few that currently do so.

An issue particular to Introductory Statistics courses is the wide variety of technologies available to perform tedious computations; from traditional reference tables to scientific calculators to professional data analysis software. Final results often vary slightly depending on which technology is used, but many existing WeBWorK problems require a specific convention or technology to get the correct answer (often without explicit indication of what should be used). Instructors who prefer an alternate methodology or students who do not have access to the requisite technology will have difficulties using these problems.

We propose to create a collection of enhanced Introductory Statistics problems and assignments to address the above deficiencies in the existing WeBWorK library by both revising existing OPL problems and creating new exercises. Content will roughly follow Chapters 8 through 12 in the OpenStax Introductory Statistics text but should be usable across a wide variety of texts (or with no text at all). Specifically:

- Dynamically-generated examples with step-by-step solutions will be available.
- Problems will provide more useful feedback, identify common errors when appropriate, and help students discover and correct their own mistakes.
- Support for at least one no-cost technology (Geogebra) will be included.
- Instructors who require that students use a particular technology (or set of technologies) will be able to do so more easily.
- Clear and concise guides for using these resources will be included.

Original Proposed Timeline:

- June-July 2019: Team members determine learning objectives to be addressed by WeBWorK questions and examples.
- September-October 2019: Team members create/revise WeBWorK questions and dynamic examples for Chapter 8 (Confidence Intervals) and Chapter 9 (One-Sample Hypothesis Tests).
- November 2019: Field test Chapters 8 and 9 questions with students.

- November-December 2019: Team members create/revise questions and dynamic examples for Chapter 10 (Two-Sample Hypothesis Tests) and Chapter 11 (The Chi-square Distribution).
- January-February 2020: Team members create/revise questions and dynamic examples for Chapter 12 (Linear Regression and Correlation).
- March-April 2020: Field test Chapters 10, 11, and 12 questions with students.
- May 2020: Finalize and publish all problem sets.

Modification of Existing Resources:

The Clayton State Mathematics Department has adopted *OpenStax Introductory Statistics* (https://openstax.org/details/books/introductory-statistics) as the official textbook for Elementary Statistics (MATH 1401). Chapter designations for our problems correspond to that text, but are sufficiently general to be used in any introductory statistics course.

Implementation:

The Clayton State Mathematics Department has used an on-campus WeBWorK server since 2012 and has used WeBWorK in all Introductory/Elementary Statistics courses (Math 1231/1401) since 2016. The server itself is now managed by the campus-wide Division of Information Technology Services, although our project lead (Dr. Dancs) has limited administrative permissions. Given the existing well-established WeBWorK infrastructure, we did not need to be concerned with technology support.

Prior to this project, both team members had taught the basic statistics course for many years. Both had significant experience writing WeBWorK problems, including problems specifically for statistics. We built upon this experience, in many cases modifying or enhancing existing problems from earlier courses, but also creating completely new ones. We found it helpful to set-up an isolated WeBWorK course, not accessible by students, for the purpose of developing and testing problems prior to actual deployment.

Problems were deployed and tested across several sections of Math 1401 during Fall 2019 and Spring 2020; roughly one-hundred students worked these problems as part of their regular course assignments. Problems that contain randomization

(essentially all of the problems that we developed) are automatically randomized by WeBWorK for each student. WeBWorK also has a built-in mechanism that allows students to contact their instructor with questions or comments about a specific problem; this provides the instructor with the exact version of a problem, including randomization, seen by the student. As students are not hesitant to use this feature, we took at as an opportunity to identify and correct any issues that we might have missed. Although we cannot guarantee full coverage in testing, we are confident that our final problems will work as expected for nearly all, if not all cases.

In order to better track changes and necessary fixes in our problems, we used the free Git software (https://git-scm.com/); an open-source distributed version control system widely used in software development. We maintained a private repository on Github (https://github.com/), which provides basic Git functionality and additional features tailored to collaborative and large-scale projects. A full discussion of these activities is beyond the scope of this report.

Lessons Learned:

We have several years of experience writing WeBWorK problems and using the software tools described above, and said experience was extremely beneficial. Some observations for the benefit of those who might consider a similar project in the future, or make use of the resources we've developed:

- Writing dynamically-generated auto-graded problems with useful feedback requires thorough knowledge of and experience with the subject material. It is crucial to be able to understand and anticipate student mistakes, even non-obvious ones.
- This being said, it is impossible to account for every possible mistake that might possibly occur. To borrow a paradigm from software development; catch only the errors you can reasonable handle.
- WeBWorK makes use of several different frameworks (including TeX/LaTeX, the PERL programming language, and the PGML markup language), and it takes some experience and practice to get them to work well together.
- The structure provided by WeBWorK alone is not conducive to large-scale development and testing (of course, it was never intended to be). Be

prepared to supplement the WeBWorK system with additional tools. Basic knowledge of computer system administration and software engineering is invaluable.

- Students often need to be reminded that, although they are using a system that automatically evaluates their work, no such system is perfect. It is acceptable and even recommended to ask a human instructor for help!

2. Materials Description

A collection of problems for use with the WeBWorK open-source online homework system. Covers Chapters 8 through 12 in *OpenStax Introductory Statistics,* but designed for use in any introductory-level statistics course.

3. Materials Links

In addition to the static version hosted on the Gallelio OER site, this collection will be available (with any updates) at https://github.com/PigSupreme/[[reponame]].

4. Future Plans

In case there is a need for updates or bugfixes, this problem collection will be maintained at https://github.com/PigSupreme/webwork-stats. This is a public GitHub repository, and additional contributions or suggestions will be welcome.

If possible, we would like to integrate these problems into the WeBWorK Open Problem Library.