

Math Pathways to Completion (MPC)  
Math& 146 Recommendation  
November 20, 2017  
Prepared and Submitted by Helen Burn

The MPC leadership team makes the following recommendations regarding statistics pathway (Math& 146) offered in colleges under the State Board of Community and Technical Colleges (SBCTC). These recommendations are based on research conducted during the summer of 2017 involving instructors and professors of statistics from SBCTC colleges and baccalaureate-granting institutions in Washington. Details of this research are provided after the recommendations.

**RECOMMENDATION 1:** Course objectives for common course numbered Math& 146 should be developed locally by SBCTC colleges but should be consistent in including the six content areas below.

- Broad understanding of statistics, including vocabulary and communication, statistical literacy (e.g., being a critical consumer of statistical studies or results)
- Descriptive statistics for univariate data, including data summaries, graphical displays, descriptive statistics, numerical summaries; organizing data
- Descriptive statistics for bivariate data, including linear regression modeling
- Study design, including data collection (e.g., sampling), design of experiments (experimental versus observational studies).
- Probability and foundations of inference, including elementary probability, contingency tables, basic probability models and distributions, normal distribution, sampling distributions (discrete-binomial; continuous, foundations of inference)
- Statistical inference: hypothesis tests and confidence intervals, including ideas behind statistical inference (“why/how”). Include confidence intervals for population mean or proportion; hypothesis testing should include one- and two-sample hypothesis testing (means or proportions, not necessarily both) and, because of its importance to experimental design, mean differences (pre-post testing). Other advanced hypothesis testing at your discretion (e.g., bivariate Chi Sq, Inference for Regression)

**RECOMMENDATION 2:** Seek commitment of Washington baccalaureate institutions regarding the following statement:

Under these recommendations, Math& 146 in the SBCTC systems will transfer as follows:

- Eastern Washington University: Math& 121: Introductory Statistics
- Western Washington: Math 240: Intro to Statistics (requires two out of three: ANOVA, Chi-Square, Linear Regression)
- University of Washington: Math 220: Basic Statistical Literacy (current default) or Math 221 (we continue to seek clarification)
- Washington State University: Uncertain
- Central Washington University: Business 221 or Math 311 (depending on student need)
- The Evergreen State College: Uncertain

**RECOMMENDATION 3:** Offer webinar on these recommendations including curriculum models for pacing and approaches for a 10-week Math& 146 course. Webinar would include representatives from several SBCTC colleges whose course objectives currently include the six content areas. Additional webinar topics should include: building consensus around depth and breadth of treatment of the following content areas: broad understanding/statistical literacy, study design, probability, inferential statistics.

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#### RESEARCH INFORMING THESE RECOMMENDATIONS

A webinar on challenges with Math& 146 held June 5, 2017, created awareness of several issues, including: Inconsistent expectations in a common course numbered course; differential transfer to baccalaureate institutions, questions about statistical needs for the majority health sciences majors in the course; uncertainty about how to promote Statway within our state given these constraints.

A webinar about intro stats in Washington baccalaureate institutions held July 21, 2017, with representatives from Eastern Washington University, Western Washington University, and University of Washington revealed diversity of student learning objectives for intro stats at these colleges.

On August 7, 2017, a group of teachers of statistics from among Washington's two- and four-year colleges and universities met at the Georgetown Campus of South Seattle College to identify major content areas and goals for Math& 146 based on reviewing Math& 146 course outcomes from a sample of colleges and curriculum recommendations related to introductory statistics. The group was also presented with research about the needs of health science majors in statistics. This meeting will be referred to through this document as the *Georgetown meeting*. The results of the Georgetown meeting were circulated afterwards and member-checked with the group present. There were no significant adjustments the meeting summary notes.

As a next step, MPC co-chair Helen Burn created a survey using Survey Monkey seeking to seek system-wide feedback from colleges in the Washington SBCTC system about whether their current Math& 146 learning outcomes included the major content areas identified in the summer meeting.

The survey (Survey Monkey) ran from October 3 through October 20, 2017. There were 23 respondents, representing 20 unique colleges in the SBCTC system, including large and small colleges and colleges from the east, west, and middle regions of Washington.

For each of the content areas below, respondents were asked to paste their current Math& 146 learning objective that most closely matches this.

- Broad understanding of statistics, including vocabulary and communication, statistical literature (e.g., being a critical consumer of statistical studies or results)
- Descriptive statistics for univariate data, including data summaries, graphical displays, descriptive statistics, numerical summaries; organizing data
- Descriptive statistics for bivariate data, including linear regression modeling

- Study design, including data collection (e.g., sampling), design of experiments (experimental versus observational studies).
- Probability and foundations of inference, including elementary probability, contingency tables, basic probability models and distributions, normal distribution, sampling distributions (discrete-binomial ; continuous, foundations of inference)
- Hypothesis tests, confidence intervals, statistical inference , including ideas behind statistical inference, confidence Intervals (means and proportions), hypothesis testing (“why/how”), hypothesis testing Big 5 (one- and two-sample mean and proportion, mean difference), other advanced hypothesis testing at your discretion (e.g., bivariate Chi Sq, Regression)

For ease of reading, these six content areas will be referred to as: Broad understanding, Univariate Descriptives, Bivariate Descriptives, Study Design, Probability, and Inferential Statistics

**Finding 1: The majority of respondents agreed about the need to establish content guidelines for Math& 146.**

18 respondents (78%) agreed strongly (n = 8) or somewhat (n = 10) that they personally agreed with the need to establish content expectations for Math& 146 needed. An additional 2 faculty indicated “Don’t Know” and 3 (13%) disagreed strongly (n = 2) or somewhat (n = 1).

**Finding 2: Math& 146 course objectives tended to include all content areas except Broad Understanding and Study Design.**

Several respondents stated that Broad Understanding is intertwined throughout the course. Other respondents posted an outcome that may imply this content area. In the case of Study Design, some conveyed that this was covered through a related outcome (e.g., sample selection), but my sense is that this outcome needs to be clarified. To help this effort, I include below the description developed in the Georgetown meeting:

Study design (consensus that this is really important for health sciences majors)

- Data collection (e.g., sampling); where data come from
- Design of experiments (experimental versus observational studies)

**Finding 2: No college had additional course outcomes outside the six content areas identified in the Georgetown meeting**

When asked if their college had Math& 146 outcomes outside the list of six, five respondents pasted outcomes, but my judgment is that all of them could be subsumed under the larger six categories (e.g., percentiles for normally distributed data). Other respondents pasted general mathematical outcomes (e.g., apply multiple strategies to problem solving). The latter suggests the need to allow some institutional flexibility in establishing course outcomes that may be required as part of department-wide or campus-wide outcomes.

**Findings 3: Probability outcomes were inconsistent across the colleges**

Learning outcomes for probability varied, and appeared independent of the dev math model of the college. In other words, there were colleges that required fewer dev math courses for students taking

Math& 146, yet had a traditional or extensive treatment of probability. The variability shown in the examples below suggest the need to clarify expectations around probability for Math& 146.

Compute probabilities based on chance • Analyze random and binomial distributions • Use the normal distribution to determine probabilities

Demonstrate an understanding of the role of probability in the study of statistics. Demonstrate an understanding and use the basic laws of probability. Use formulas predicting mathematical expectation. Demonstrate an understanding of and use the binomial probability distribution. Find areas of the normal probability distribution and apply to problem solving. Demonstrate an understanding of and use the Central Limit Theorem.

**Finding 4: Coverage of the binomial theorem and inferential statistics varied widely**

The survey asked respondents to indicate whether the binomial theorem and different types of hypothesis testing instructors in their program were expected to cover. The responses are below.

ANSWER CHOICES	RESPONSES
Binomial Distribution	60.87% 14
One sample hypothesis testing: Inference for the mean of a population	100.00% 23
Two-sample hypothesis testing: Comparing two means	60.87% 14
One sample hypothesis testing: Inference for a population proportion	91.30% 21
Two-sample hypothesis testing: Comparing two proportions	56.52% 13
One-sample hypothesis testing: Mean difference (e.g., pre-post test)	60.87% 14
Chi-square tests	21.74% 5
Inference for regression	34.78% 8
Total Respondents: 23	

Looking at the responses individually, they ranged from a low of expecting only inference for the mean of a population, to colleges that expected instructors to cover the “Big 5” (options 2-6 in the table) or the Big 5 plus Chi-Square. It is also noteworthy that all but one college covered Linear Regression, but only 8 covered inference for regression. Also noteworthy is that two respondents indicated their college expected Big 5, Chi Square, and Linear regression and these colleges had a tailored stats prep pathway or an off ramps model through dev math.