

Development of A Student-Driven, Evidence- and Data-Based Grading Scale for CHEM 121:

Fall 2019 Implementation

Prepared by

Franklin S. Carman III, Ph.D., Professor of Biophysical Sciences

WNC-Carson City Campus

In Partial Fulfillment of

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Annual Plan for Academic Year 2019-2020

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Table of Contents.....	Page
Abstract/Executive Summary.....	4 of 35
Terms and/or Definitions.....	5 of 35
Introduction.....	5 of 35
Methods.....	6 of 35
Results.....	6 of 35
Discussion.....	7 of 35
Conclusions, Recommendations and Future Actions.....	10 of 35

Appendices

Appendix 1.....	12 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #1: Canvas-Based Five Semesters' Review of Scores

Appendix 2.....	14 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #2: Canvas-Based Five Semesters' Review of Scores

Appendix 3.....	16 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #3: Canvas-Based Five Semesters' Review of Scores

Appendix 4.....	18 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #4: Canvas-Based Five Semesters' Review of Scores

Appendix 5.....	20 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #5: Canvas-Based Five Semesters' Review of Scores

Appendix 6.....	22 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #6: Canvas-Based Five Semesters' Review of Scores

Appendix 7.....	24 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #7: Canvas-Based Five Semesters' Review of Scores

Appendix 8.....	26 of 35
-----------------	----------

2017-01-2019-01 NSBE/Q #1-#7 -- Averages: Canvas-Based Five Semesters' Review of Student Scores -- NSBE/Q 1-4 v NSBE/Q 5-7

Appendix 9.....28 of 35
Five Semesters' Final Course Grades – CHEM 121 -- 2017-01-2019-01

Appendix 10.....30 of 35
CHEM 121 Enrollment Review by Carson Campus Room Location – 2012-01 – 2019-01

Appendix 11.....32 of 35
2017-01-2019-01 CHEM 121 Final Course Grades (NSHE 4.0 Scale) v Students' Final Course
Per Cents as Distributed in Canvas

Appendix 12.....34 of 35
Evidence-Based/Derived Grading Scale for CHEM 121 Students' Final Course Grades'
Determination: **Effective Fall 2019**

Abstract/Executive Summary

A review of the immediately previous five (5) 16-week semesters' CHEM 121 Students' NSBE/Q's and Final Course grades was undertaken (N=89).

While there were periodically statistical NSBE/Q differences (statistical differences ranged as $p < 0.05$ or less) between occasional semesters' NSBE/Q's, there were no substantial differences to suggest what to do or what not to do to aid in students demonstrating learning about CHEM 121 as part of this specific study.

When the NSBE/Q's were examined as overall averages, it was clear, however, that there were statistical (as well as obviously visual) differences between NSBE/Q's 1-4 and NSBE/Q's 5-7 scores, $p \lll 0.001$. The former group is administered during the first half of the course and the latter group is administered during the latter half of the course.

As a result of the average NSBE/Q differences, the final course percentages as determined by distribution in Canvas) were examined against the students' recorded final course grades in myWNC. From that study, a grading scale was experimentally derived that includes the student's final course percent (as distributed in Canvas) to determine the final course grade per the NSHE 4.0 GPA scale: $y = 0.0665x - 2.0473$ (x = student's Canvas final calculated course percent score; y = student's final letter grade for recording purposes as defined by the NSHE 0 → 4.0 GPA scale).

In Fall 2019, CHEM 121 is being offered as an 8-week course. As a result of this scheduling, numerous changes have to occur. These changes, non-inclusively, consist of reducing the number of NSBE/Q's to fit the shorter "semester", reducing the number of problem set assignments, adjusting exam questions to reflect mastery rather than performance and implement more traditional in-class methodologies of/for instruction ... without impacting (i.e., causing a reduction in) the appropriate rigor of the course.

301 Words; Flesch-Kincaid Level 16.8

Terms and/or Definitions

Mastery: Demonstrating continuous improvement towards learning about a fixed body of knowledge; determined, overall, statistically using Difficulty and Discriminatory Indices embedded in Canvas.

NSBE/Q: Not So Big Exam/Quiz; the name was originally developed in an attempt to reduce the anxiety many students feel before an exam in BIOL and CHEM courses.

Performance: Demonstrating on examination at some degree ranging between the “best” and the “worst” scores.

Introduction

Approximately six (6) years ago, the author began experimenting with non-traditional classroom “flipping” approaches regarding chemistry education for students. In the early stages, the approaches appeared to be working as previously reported in long forgotten self-evaluations.

One example of the caliber of student in the initial days of “flipping” the course was a student who had completed CHEM 121 three semesters previously (in a non-flipped version of CHEM 121) at a B/B+ level, who returned for grade improvement three semesters later. That student increased his/her recorded CHEM 121 grade to an A-. The student’s goal was to attend UNLV’s DPT program. That student graduated recently with the DPT degree.

Prior to the mandated faculty implementation of Canvas, generating, storing and retrieving files of a spreadsheet nature was a bit cumbersome as they were easily “lost”, names were forgotten, ad nauseum. Canvas, while not exactly perfect, however, has a big feature (besides being great evidenciary recordation) that makes it quite useful: the files remain for a substantial period of time and can easily be retrieved (even with intermittent internet service) for assessment studies (as well as by administrative personnel reviewing student discussions ... dissensions???)

Canvas has been used by the author, now, for five (5) semesters. A variety of approaches to promote student learning regarding CHEM 121 have been utilized (cf [1](#), pp 9 and 22 of 29) and changes constructed and implemented, [ibid](#).

This particular meta-analysis/assessment study is a product of examining five (5) semesters’ worth of Canvas-based CHEM 121 student data in the continuing struggle to effect meaningful methodologies to positively impact students in such a manner that they will demonstrate academically appropriate levels of knowledge: at the very least to demonstrate adequate mastery of the topic; at the most to demonstrate high performance levels on exams.

Methods

NSBE/Q data was studied per Excel. The usual Hi, Mean and Lo scores were determined and prepared for optimal viewing. Typical Students' 2-tailed t-test for significance was utilized.

Final Course Grades and Final Course Percents were, likewise, prepared via Excel for optimal viewing and analysis. In the case of this data, standard deviation and half-standard deviations were employed.

Results

The reader is referred to individual **Appendices** (1-12, in order, below) regarding visual references to the following text.

Compared to the average of NSBE/Q #1, only Fall 2018 and Spring 2019 scores are statistically different from the five-semester average, lower and higher, respectively, $p < 0.01$ and $p \lll 0.001$.

Compared to the average of NSBE/Q #2, there are no statistical differences across the five semesters.

Compared to the average of NSBE/Q #3, there are no statistical differences across the five semesters.

Compared to the average of NSBE/Q #4, there are no statistical differences across the five semesters.

Compared to the average of NSBE/Q #5, only Fall 2017 and Spring 2018 scores are statistically different from the five-semester average, higher and lower, respectively, $p < 0.01$ and $p < 0.05$.

Compared to the average of NSBE/Q #6, only Fall 2018 scores are statistically different from the five-semester average, lower, respectively, $p < 0.05$.

Compared to the average of NSBE/Q #7, only Spring 2017, Fall 2017 and Spring 2019 scores are statistically different from the five-semester average, lower, lower and higher, respectively, all $p < 0.01$.

When the average scores of NSBE/Q #1-4 are compared to those of NSBE/Q #5-7, the latter are statistically different (lower) from the former, 64% v 49%, respectively, $p \lll 0.001$.

Appendix 9 provides a graphic representation of the five (5) individual CHEM 121 courses' (Sp 2017-Sp 2019) students' final grades using NSHE's 4.0 grading scale. All final grades show no statistically significant difference against the overall five semesters' average.

Appendix 10 provides direct graphic representations of CHEM 121 class enrollments from Spring 2012 through Spring 2019 by Carson campus room location and indirect by classroom physical space (REYN 103 is capped at 66 students; new CED 305 is capped at 36 students; new CED 310 is capped at 30 students; the recently re-modeled 201 ASP is capped at 32 students).

Appendix 11 provides an illustration of the experimentally derived approach to the grading scale for CHEM 121 effective Fall 2019: $y = 0.0665x - 2.0473$ (**x = student's final course score percent in Canvas; y = student's final letter grade for recording purposes as defined by the NSHE 0 → 4.0 GPA scale**).

Appendix 12 correlates/tabulates the final course score percent range for the final reported letter grade (and NSHE 4.0 GPA equivalent) effective Fall 2019.

Discussion

NSBE/Q	Sp 2017	F 2017	Sp 2018	F 2018	Sp 2019
1				✓↓	✓↑
2					
3					
4					
5		✓↑	✓↓		
6				✓↓	
7	✓↓	✓↓			✓↑

Table 1. Summary of statistical differences of NSBE/Q by semester. KEY: ✓ = statistically significantly different against the average per Results and Appendices 1-7; ↑ or ↓ = above or below the average per Results and Appendices 1-7. Remainder blacked out are NSD.

Table 1, above summarizes NSBE/Q's that were statistically different from the average for each individual NSBE/Q. As previously stated, CHEM 121 has, for a number of years been "flipped", non-traditionally. That "flip" was based on data within the previous lustrum, plus or minus a year or two. At that time, students were performing at a higher level and the flip seemed reasonable to increase/improve student learning.

As can be seen in both Appendices 8 and 9, neither the NSBE/Q scores nor the overall course grades reflect a great deal of improvement, semester-to-semester.

Appendix 8 reflects an interesting phenomenon: the first four students' NSBE/Q scores are statistically significantly higher than the last three students' NSBE/Q scores as pointed out in

Results. The first four exams are administered in the first half of the course and the last three are administered in the last half of the course, regardless of semester (i.e., Fall or Spring).

There are at least three possible explanations that jump out: 1) Students are fresher in the first half of the semester and are better prepared for the first four exams and are tired during the last half of the semester and don't exert themselves in that time span, 2) the first four exams are not as rigorous as the last three exams or 3) the first four exams are preparatory, as well as review, in preparation for the progressively more complex, complicated and/or advanced course information and the students are not putting in the necessary time to master the succeeding content.

During Spring 2019, the reporter increased more traditional lecture format styles, including emailing the annotated PowerPoint lectures to each student for their review: particularly in the last half of the course.

In addition, while subtle, since students have been in the Wm N. Pennington Biophysical Sciences lab for office hours, lecture and lab, there has been a continual improvement in their final scores/grades, on average, albeit non-statistically different.

In the semester prior to the remodel and the semester peri-remodel, average overall student course final grades were lower (in the old 201 ASP as it was being stripped down), yet higher (in the slammed together "re-mix" of 329 BRIS) during the re-model in ASP, respectively. In addition, the High and Median final course grades have, likewise, been higher since using the new lab.

Of equal interest is the impact of the larger lab on class size and retention, **Appendix 10**: this topic is explored and specifically addressed in a recently e-submitted (and uploaded) report [2].

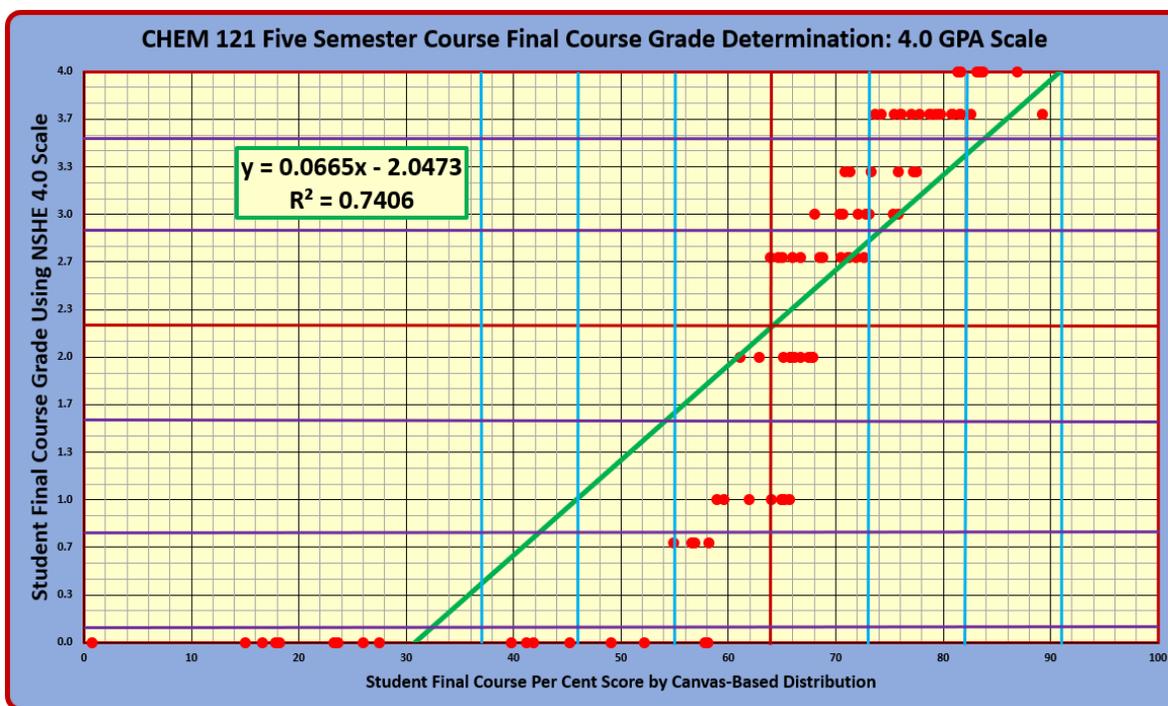
Upon review of NSBE/Q's 1-7 (NSBE/Q 8 was removed from Spring 2019 course content and was not included in any NSBE/Q data review for this assessment project [3]) and **Table 1**, it was clear that, with few exceptions, students' performances had, basically, stabilized (become stagnant?) using the "flip methodology". In and of itself, that's not a bad thing: Faculty have for years (cf co-author Glenn Seaborg's Report "**A Nation at Risk: The Imperative for Educational Reform -- A Report to the Nation and the Secretary of Education, United States Department of Education by The National Commission on Excellence in Education, April 1983**" [4]) complained that students are/were getting worse from an academic perspective and course content is/was becoming less and less rigorous (this author refers the reader to pp 9, the 2d and 3d paragraphs for the seriousness of this report, to succinct wit: "*We have, in effect, been committing an act of unthinking, unilateral educational disarmament*" [lbid](#)).

This review suggests that the former hasn't been the case in General Chemistry I at WNC for at least five (5) semesters, while the latter might be somewhat supported inasmuch as NSBE/Q 8 and its content was removed from General Chemistry as previously stated. Note also that the content for NSBE/Q 8, while not of traditional General Chemistry I instruction, was originally implemented to provide some academic support for WNC's pre-NURS students who took CHEM

121 (rather than BIOL 190) as “preparation” for BIOL 223, 224 and 251, hence, removing the content wasn’t really a “dumbing-down” action.

Given the apparent “grade performance” stability, the seven (7) NSBE/Q’s were averaged together as individual exams (**Appendix 8**) and the pre-mid-term v post-mid-term exam score pattern jumped off the page ($p < 0.001$). As a result of this pattern of exam performances, **Appendix 9** was developed to look at the overall students’ final course grades (all NSD). Given the “constancy” of these students’ grades, the five (5) semesters’ worth of final grades (using the NSHE 4.0 grading scale [5]) were plotted against the students’ final course percentages (as stored in Canvas), **Appendix 11**.

The image from **Appendix 11** is reproduced in smaller format below for discussion/clarification purposes:



There are a number of overlaying lines on the graphic, above. The two (2) maroon lines represent the intersection of the average course grade (GPA) with the average final course percent score. The horizontal purple lines represent the starting point to separate grades into the NSHE GPA system. The light blue vertical lines were the starting point for separating out percent scores into “grading blocks”. The green diagonal line represents the best fit line using Excel’s “trend line” (basically a fancy name for a linear regression line). The very best correlation of this data to a generated curve in Excel was actually using a 6th degree polynomial with an R^2 of 0.98. This curve, however, was practically-speaking useless for determining a grading curve based upon this evidence. Hence, the linear approach was taken.

Appendix 12 summarizes the grading scale that was established and is to be implemented to four (4) significant figures during Fall 2019 CHEM 121. Of interest is that this scale isn't that far off the grading scale this author began using at WNC[C] in 1990. In addition, this approach will be utilized, again, for the four (4) accelerated BIOL courses also taught by the author, using those courses' data, of course! Whether it gets implemented for BIOL this Fall (2019) or not is still up in the air.

Conclusions, Recommendations and Future Actions

In short, using student-derived data, this assessment project has provided insights for the development of a mastery-based approach to learning, to the development of a data-driven grading scale for students' final course grades and has provided a statistical direction to go to give mastery driven exams in support of content mastery rather than simply performance (guessing games). It's also likely that moving to a mastery-driven approach will direct/guide faculty in a comprehensive review, and probably changes, of, in, to or with, the current CHEM 121 Student Learning Outcomes that were developed, oh, so long ago.

In addition, as a result of this exploration, numerous changes have to occur in CHEM 121. These changes, non-inclusively, consist of reducing the number of NSBE/Q's to fit the shorter "semester", reducing the number of problem set assignments, adjusting exam questions to reflect mastery rather than performance and implement more traditional in-class methodologies of/for instruction ... without impacting (i.e., causing a reduction in) the appropriate rigor of the course.

Appendices

Key to Statistics: Semester Exam Scores vs Average

(or no markings) = Not Statistically Different (NSD)

$$\text{C} = p < 0.05$$

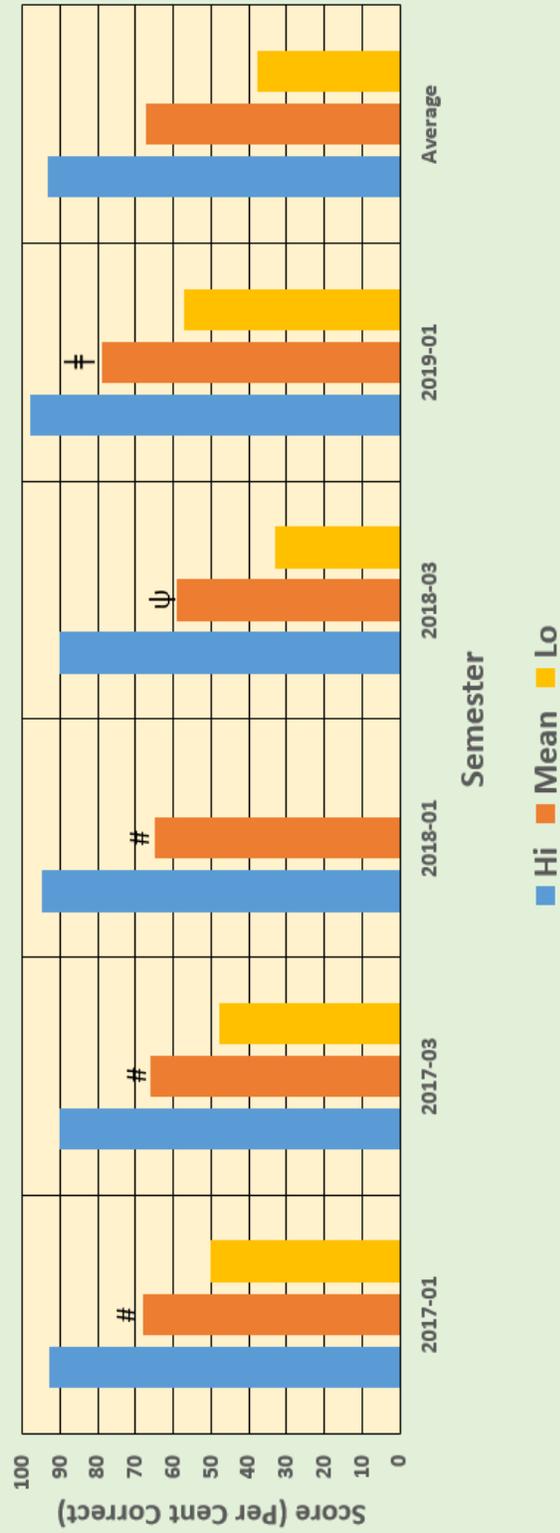
$$\Psi = p \lll 0.01$$

$$\text{‡} = p \lll 0.001$$

Appendix 1

2017-01-2019-01 NSBE/Q #1: Canvas-Based Five Semesters' Review of Scores

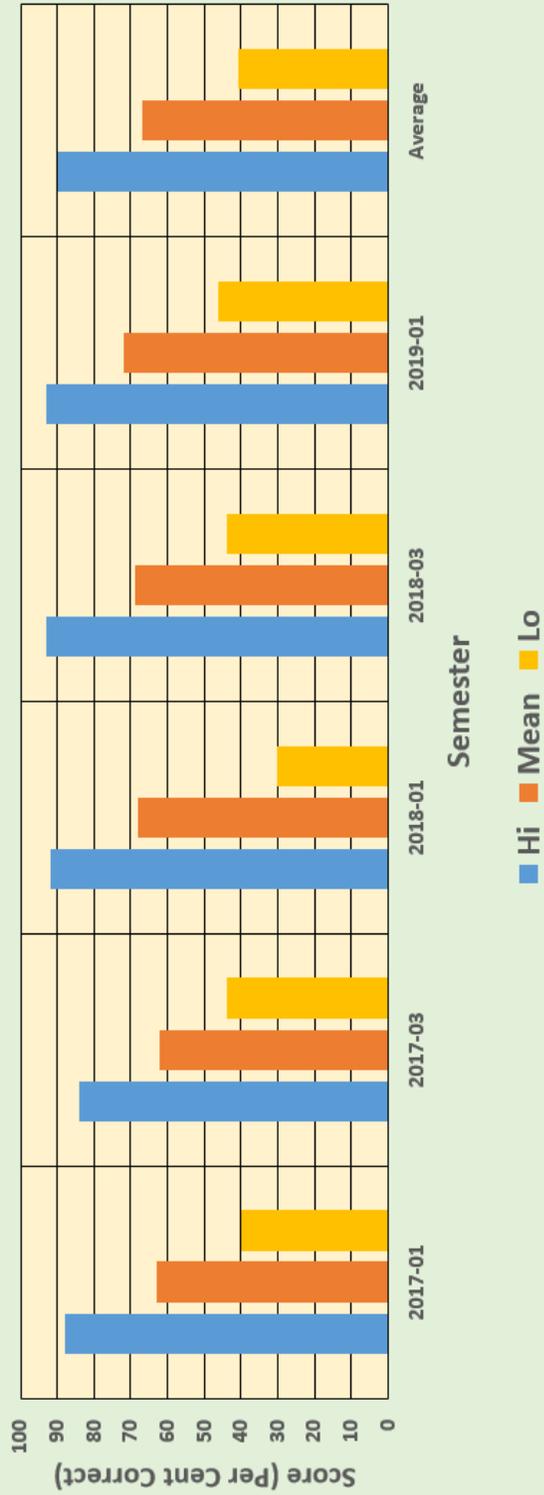
NSBE/Q #1 (MATH) -- CHEM 121 Spring 2017 - Spring 2019



Appendix 2

2017-01-2019-01 NSBE/Q #2: Canvas-Based Five Semesters' Review of Scores

NSBE/Q #2 (MATH, Lattice, Effective Charge) -- CHEM 121
 Spring 2017 - Spring 2019 -- NSD



Appendix 3

2017-01-2019-01 NSBE/Q #3: Canvas-Based Five Semesters' Review of Scores

NSBE/Q #3 (% Comp; Lim Rx; Hybrid) -- CHEM 121
 Spring 2017 - Spring 2019 -- NSD



Appendix 4

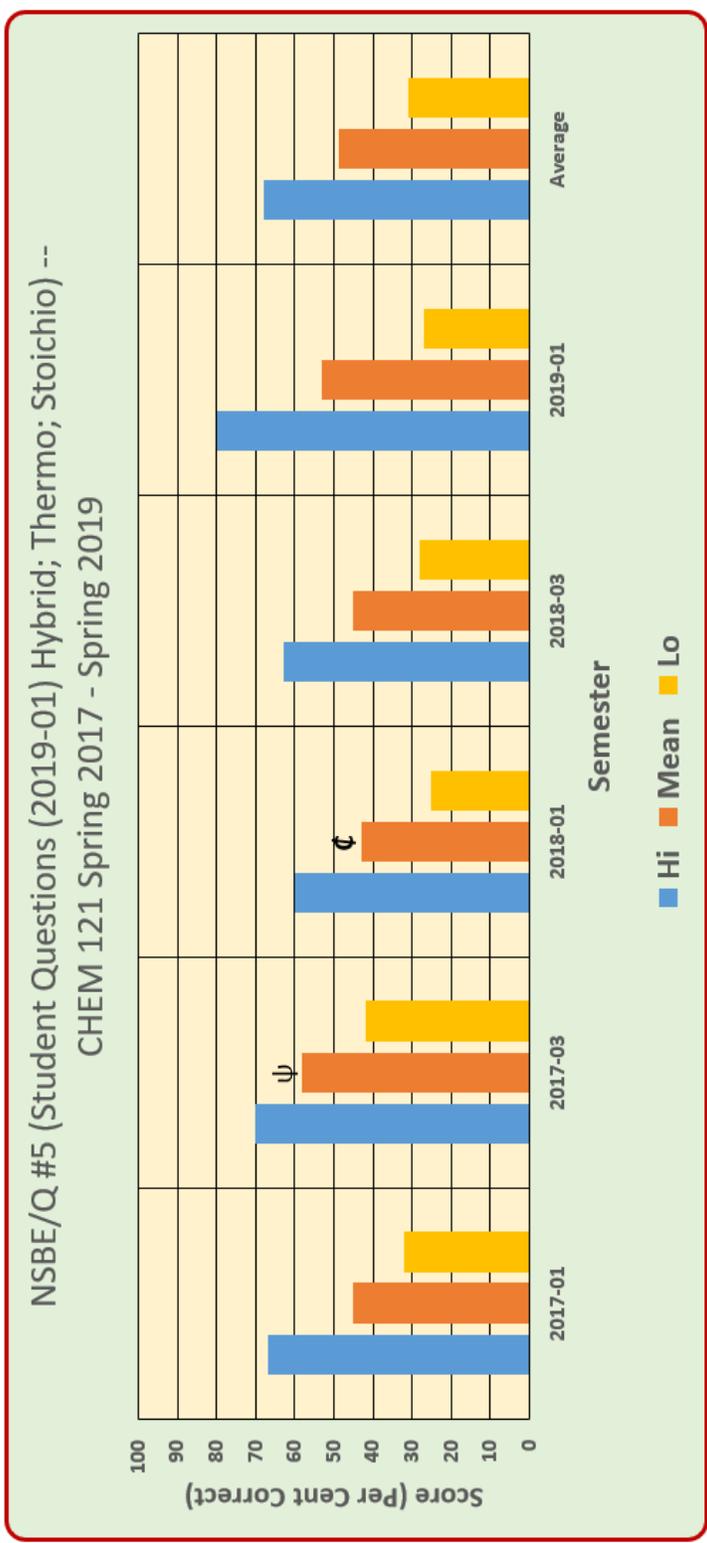
2017-01-2019-01 NSBE/Q #4: Canvas-Based Five Semesters' Review of Scores

NSBE/Q #4 (Hybrid; Thermo; Stoichio) -- CHEM 121
 Spring 2017 - Spring 2019 -- NSD



Appendix 5

2017-01-2019-01 NSBE/Q #5: Canvas-Based Five Semesters' Review of Scores



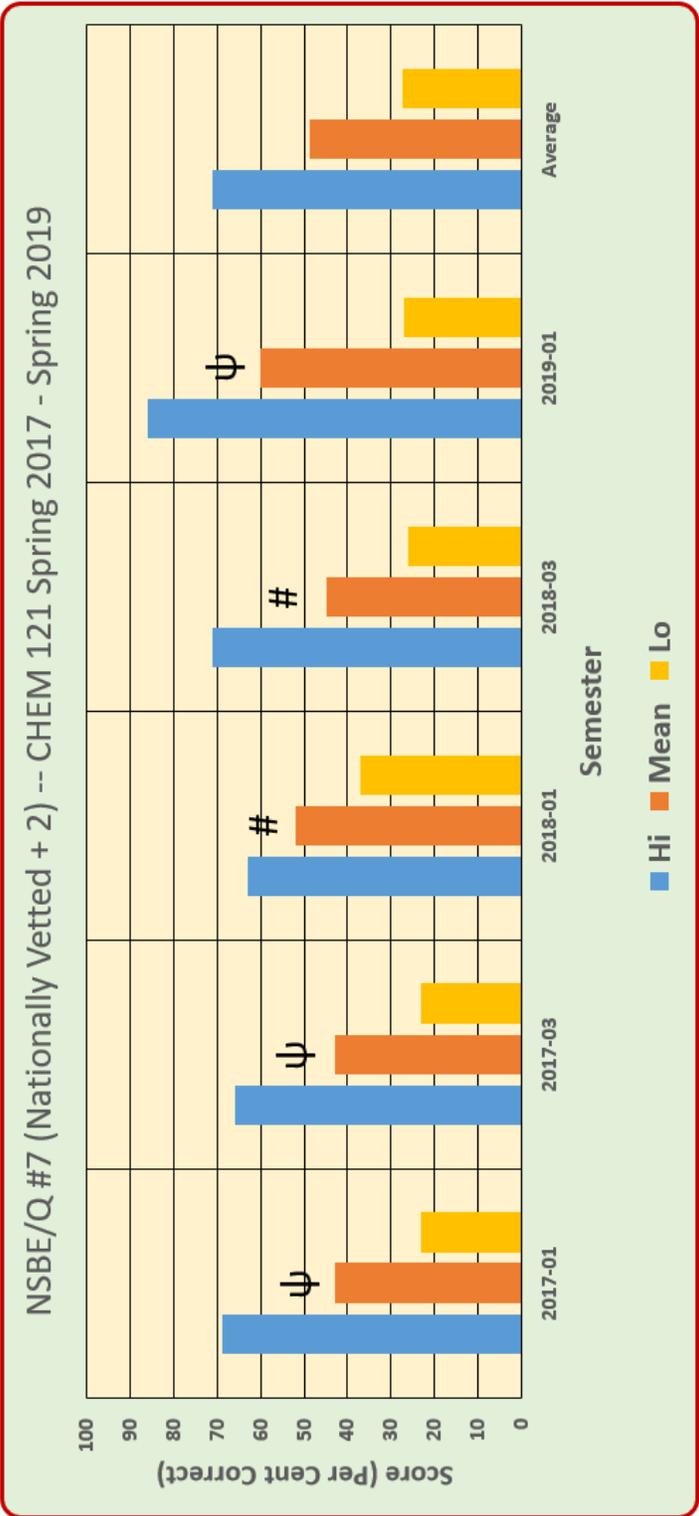
Appendix 6

2017-01-2019-01 NSBE/Q #6: Canvas-Based Five Semesters' Review of Scores



Appendix 7

2017-01-2019-01 NSBE/Q #7: Canvas-Based Five Semesters' Review of Scores

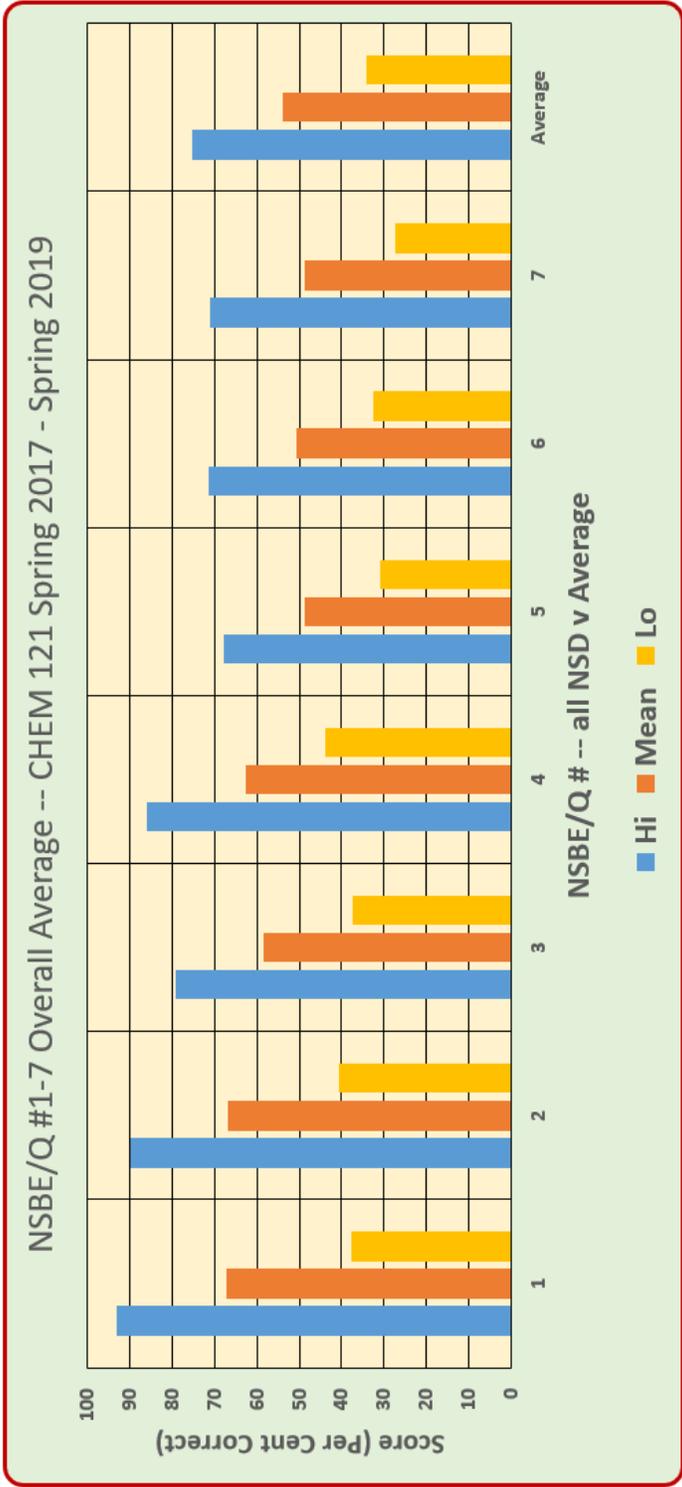


Appendix 8

2017-01-2019-01 NSBE/Q #1-#7 -- Averages:

Canvas-Based Five Semesters' Review of Student Scores

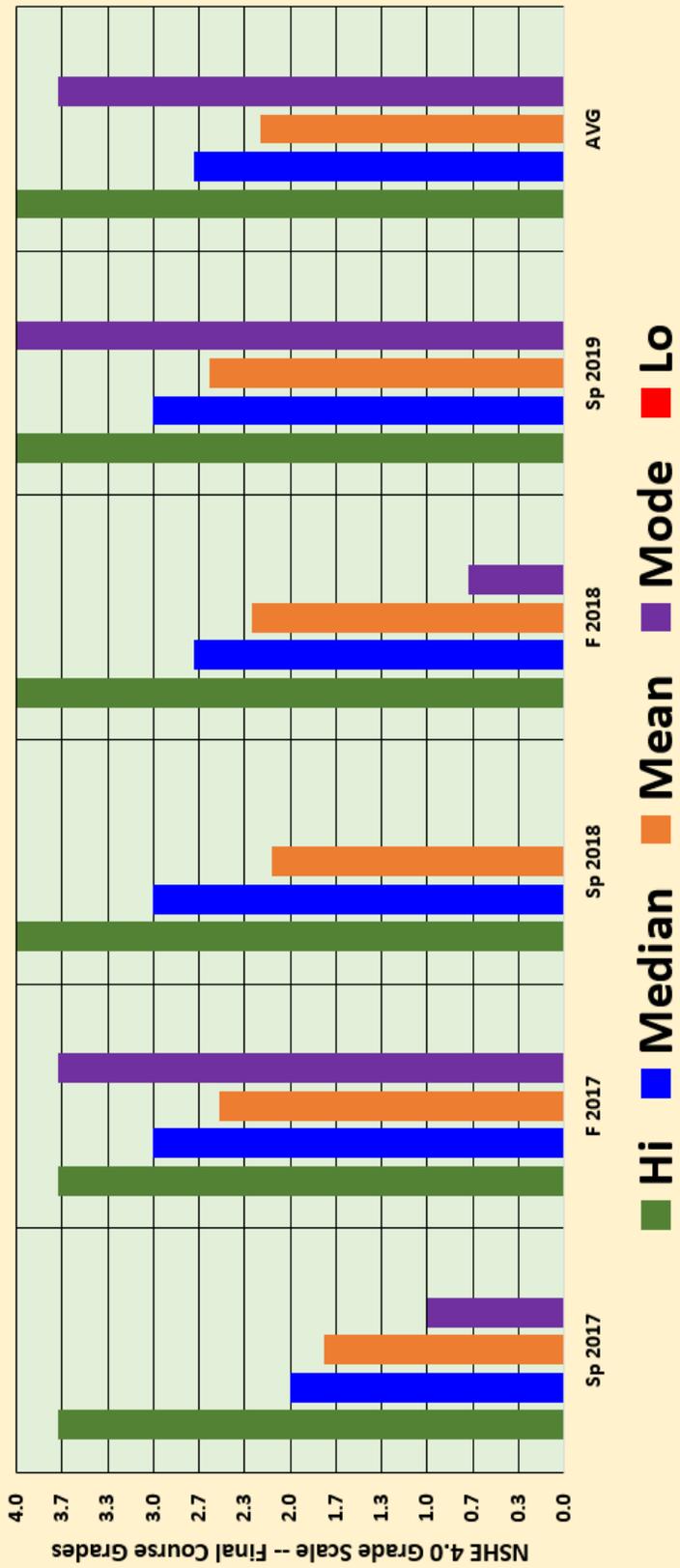
NSBE/Q 1-4 v NSBE/Q 5-7: $p \lll 0.001$



Appendix 9

Final Course Grades – CHEM 121 – Sp 2017 – Sp 2019

**Five Semesters' Final Course Grades -- CHEM 121 -- Spring 2017-Spring 2019 --
All NSD Against the Average**

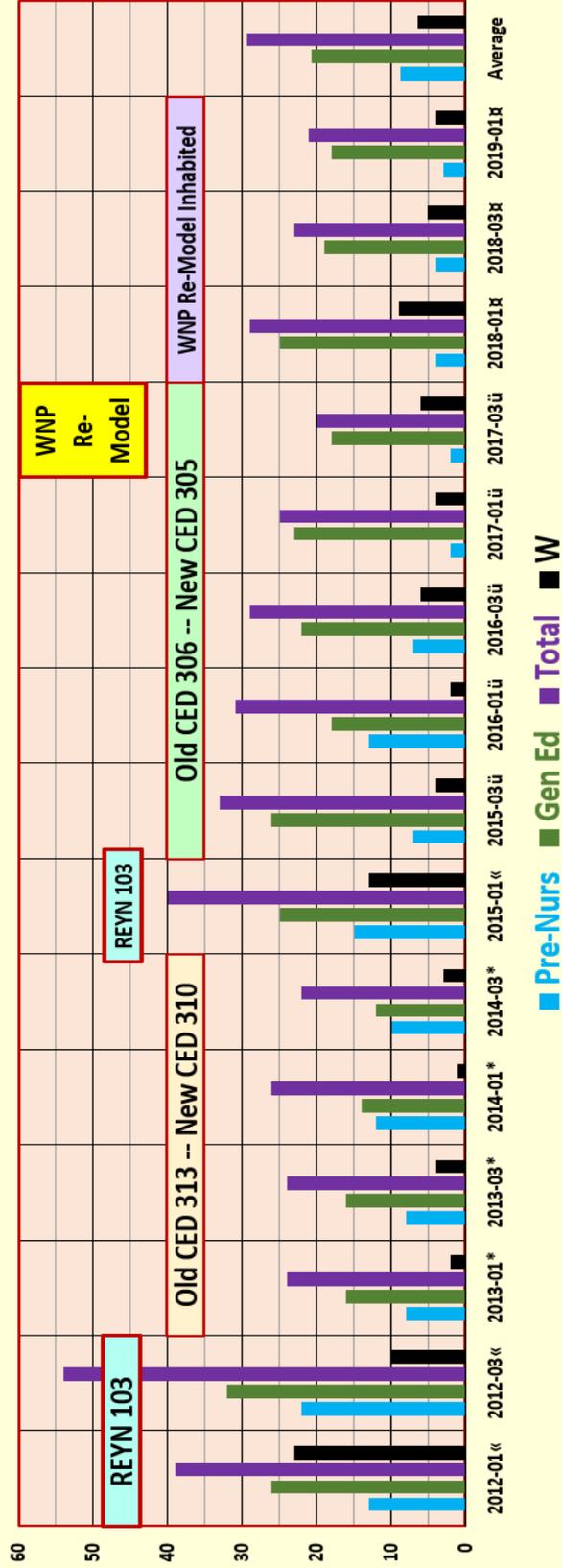


Appendix 10

Enrollment Review by Carson Campus Room Location

Spring 2012 – Spring 2019

CHEM 121 Enrollment 2012-01 Through 2019-01 by Student Category

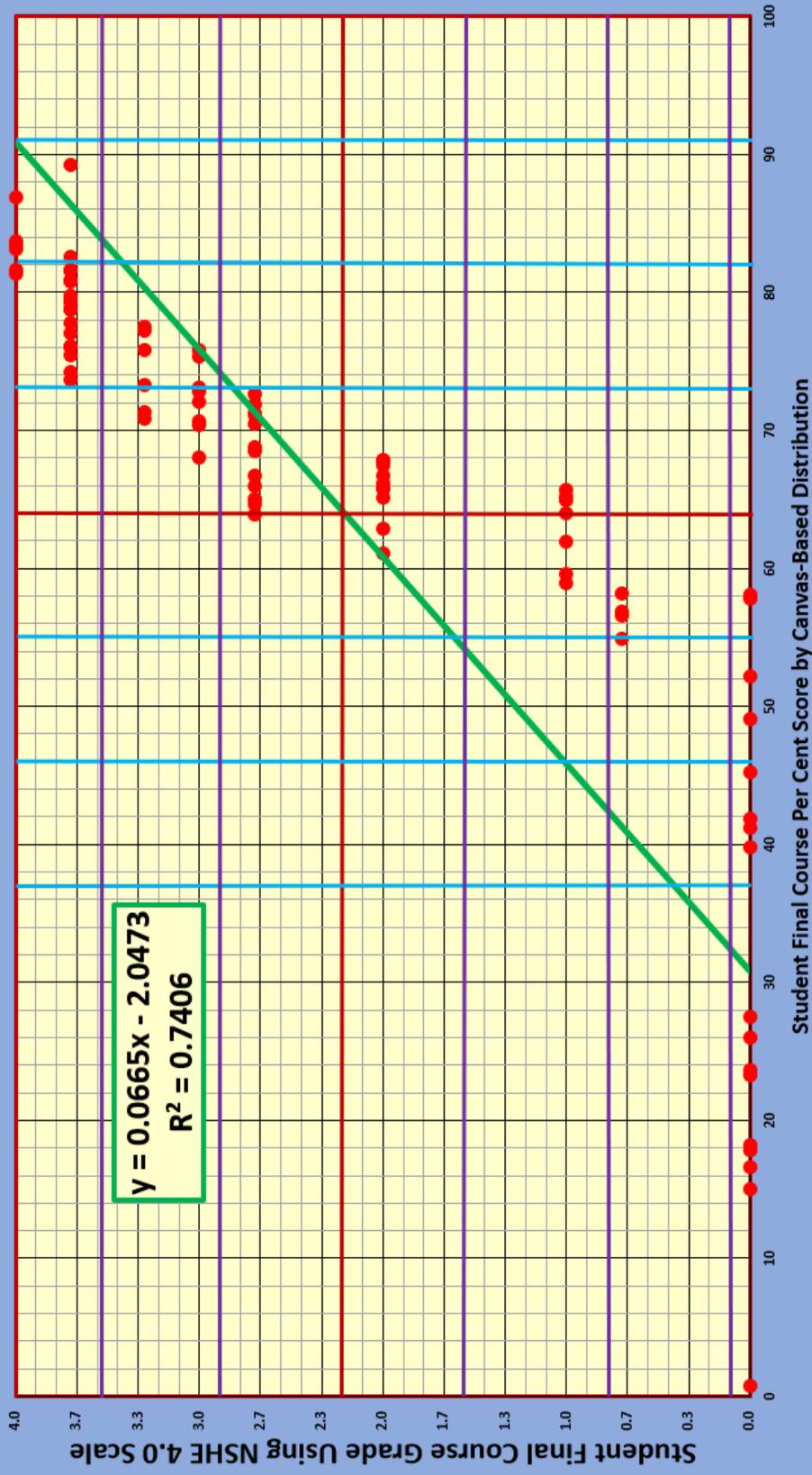


Appendix 11

2017-01-2019-01 CHEM 121

Final Course Grades (NSHE 4.0 Scale) v Students' Final
Course Per Cents as Distributed in Canvas

CHEM 121 Five Semester Course Final Course Grade Determination: 4.0 GPA Scale



Appendix 12

Evidence-Based/Derived Grading Scale for CHEM 121 Students' Final Course Grades' Determination

Effective Fall 2019

Fall 2019 CHEM 121 Grading Scale		
Student's Canvas-Based Final Course Percent (x)	Student's Calculated Final Course Grade (4.0 NSHE Scale) (y)	Recorded Letter Grade (NSHE Scale)
CHEM 121 Final Course Grade Equation:		
$y = 0.0665x - 2.0473$		
$\geq 91\%$	≥ 4.000	A
86 – 90.999 %	3.700 – 3.999	A-
80 – 85.999 %	3.300 – 3.699	B+
76 – 79.999 %	3.000 – 3.299	B
71 – 75.999 %	2.700 – 2.999	B-
65 – 70.999 %	2.300 – 2.699	C+
61 – 64.999 %	2.000 – 2.299	C
56 – 60.999 %	1.700 – 1.999	C-
50 – 55.999 %	1.300 – 1.699	D+
46 – 49.999 %	1.000 – 1.299	D
41 – 45.999 %	0.700 – 0.999	D-
$\leq 40.999\%$	≤ 0.699	F