Appendix 1

The version number (78 or 87) is based on the first multiplicand of each quiz.

Math-Up Skills Test (MUST)

PRINT: Last name: ____ **First name:** ____________________

You have 15 minutes to complete this quiz.

You **may not** use a calculator or any other electronic device. Show any needed work on this paper.

Multiply: **1.** $\begin{array}{r} 78 \\ \times 96 \\ \hline \end{array}$

2. $(0.50 \times 10^{-6})(6.4 \times 10^{21}) =$ ________________________

3. $(2.50 \times 10^{-9})(3.0 \times 10^{17}) =$ ________________________

Write these answers in decimal notation (as regular numbers/not fractions).

4. $\frac{140}{10{,}000} =$ _____ **5.** $47^{0} =$ _____ **6.** $\frac{1}{4}$ / [redacted] = __________

Simplify: **7.** $\frac{10^{5} \times 10^{23}}{10^{-1} \times 10^{-6}} =$ _______________ **8.** $\frac{9.0 \times 10^{-18}}{2.0 \times 10^{-5}} =$ _______________

Write these values as their decimal equivalents:

9. $\frac{1}{8} =$ ________________________ **10.** $\frac{1}{50} =$ ________________________

11. If $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ then solve for T_2, in symbols as one simple fraction: T_2 **=**

Determine the base-10 log of: **12.** 1000 = _____ and **13.** 0.001 = _____

Solve questions **14** and **15** and write answers in scientific notation.

14. $(3.0 \times 10^{-7})^{2} =$ ________________________ **15.** $\sqrt{64 \times 10^{-12}} =$ ________________________

16. If A = B, evaluate: $\frac{A}{A - B}$ _______________ **17.** Simplify: $\frac{25}{25 - 5}$ _______________

18. Circle equivalents of one-thousandth: 10 0.1 0.001 10^{-3} 0.01 1000 $\frac{1}{10^{3}}$ $\frac{1}{1000}$

Enter the remaining coefficients that balance these chemical equations.

19. **4** NH_3 + ______ O_2 → ______ NO + _____ H_2O

20. **12** NH_3 + ______ O_2 → ______ NO_2 + _____ H_2O

Math-Up Skills Test (MUST)

PRINT: Last name: ________________________________ **First name:** ______________

You have 15 minutes to complete this quiz.

You **may not** use a calculator or any other electronic device. Show needed work on this paper.

Multiply **1.** $\begin{array}{r} 87 \\ \times 96 \\ \hline \end{array}$

2. $(0.50\times10^{-4})\,(3.2\times10^{21}) =$ ____________________

3. $(3.50\times10^{-9})\,(2.0\times10^{17}) =$ ____________________

Write these answers in decimal notation (as regular numbers/not fractions).

4. $\frac{24}{10{,}000} =$ _____ **5.** $42^0 =$ _____ **6.** $\frac{\frac{1}{2}}{\frac{1}{3}} =$ __________

Simplify: **7.** $\frac{10^7\times10^{-23}}{10^{-1}\times10^{-6}} =$ ________________ **8.** $\frac{7.0\times10^{-18}}{2.0\times10^{-7}} =$ ________________

Write these values as their decimal equivalents:

9. $\frac{1}{8} =$ ____________________ **10.** $\frac{1}{20} =$ ____________________

11. If $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$ then solve for T_1, in symbols as one simple fraction: $T_1 =$

Determine the base-10 log of: **12.** 10,000 = _____ and **13.** 0.1 = _____

Solve questions **14** and **15** and write answers in scientific notation.

14. $(2.0\times10^{-8})^2 =$ ____________________ **15.** $\sqrt{49\times10^{-18}} =$ ____________________

16. If B = A, evaluate: $\frac{B}{B-A} =$ ______________ **17.** Simplify: $\frac{25}{25-15} =$ ________________

18. Circle equivalents of one-hundredth: $\frac{1}{10^2}$ 10^{-2} 0.02 200 0.001 $\frac{1}{100}$ 0.01 100

Enter the remaining coefficients that balance these chemical equations.

19. **4** NH_3 + ______ O_2 → ______ NO_2 + _____ H_2O

20. **12** NH_3 + ______ O_2 → ______ NO + _____ H_2O

Appendix 2

Answer keys to version numbers (78 and 87) based on the first multiplicand of each quiz.

PRINT: Last name: ____KEY________________________________ **First name:** ___________________

SCORE: 20/20

You have 15 minutes to complete this quiz.

You **may not** use a calculator or any other electronic device. Show needed work on this paper.

Multiply: **1.** 78 × 96 = 7488 (1 pt)

2. $(0.50 \times 10^{-6})(6.4 \times 10^{21})$ = ___×___

3. $(2.50 \times 10^{-9})(3.0 \times 10^{17})$ = ___×___

Write these answers in decimal notation (as regular numbers).

4. ——— = 0.014 (1 pt)

5. = 1 (1 pt)

6. $\frac{\frac{1}{4}}{\frac{1}{2}}$ = 0.5 (1 pt)

Simplify: **7.** $\frac{10^{5} \times 10^{23}}{10^{-1} \times 10^{-6}}$ = ___

8. $\frac{9.0 \times 10^{-18}}{2.0 \times 10^{-5}}$ = ___×___

Write these values as their decimal equivalents:

9. — = _____

10. — = 0.02

11. If $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ then solve for T_2, in symbols as one simple fraction: $T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$

Determine the base-10 log of: **12.** 1000 = 3 and **13.** 0.001 = -3

Solve questions **14** and **15** and write answers in scientific notation.

14. $(3.0 \times 10^{-7})^2$ = ___×___

15. $\sqrt{64 \times 10^{-12}}$ = ___×___

16. If A = B, evaluate: $\frac{A}{A-B}$ __________

17. Simplify: $\frac{25}{25-5}$ $\frac{5}{4}$, $1\frac{1}{4}$, *or* 1.25

18. Circle equivalents of one-thousandth: 10 0.1 0.001 10^{-3} 0.01 1000 $\frac{1}{10^3}$ $\frac{1}{1000}$

Enter the remaining coefficients that balance these chemical equations.

19. 4 NH_3 + __5__ O_2 → __4__ NO + __6__ H_2O

20. 12 NH_3 + __21__ O_2 → __12__ NO_2 + __18__ H_2O

PRINT: Last name: ________KEY______________________________ **First name:** ____________________

SCORE: 20/20

You have 15 minutes to complete this quiz.

You **may not** use a calculator or any other electronic device. Show needed work on this paper.

Multiply 1. 87 × 96
8352 (1 pt)

2. $(0.50 \times 10^{-4})\ (3.2 \times 10^{21}) =$ ___×___

3. $(3.50 \times 10^{-9})\ (2.0 \times 10^{17}) =$ ___×___

Write these answers in decimal notation (as regular numbers).

4. ——— = 0.0024 (1 pt) 5. = 1 (1 pt) 6. $\frac{\frac{1}{2}}{\frac{1}{3}} = 1.5$ (1 pt)

Simplify: **7.** $\frac{10^{7} \times 10^{-23}}{10^{-1} \times 10^{-6}} =$ ___ **8.** $\frac{7.0 \times 10^{-18}}{2.0 \times 10^{-7}} =$ ___×___

Write these values as their decimal equivalents:

9. — = ____ **10.** $\frac{1}{20} =$ ____

11. If $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ then solve for T_1, in symbols as one simple fraction: $T_1 = \frac{P_1 V_1 T_2}{P_2 V_2}$

Determine the base-10 log of: **12.** 10,000 = 4 and **13.** 0.1 = -1

Solve questions **14** and **15** and write answers in scientific notation.

14. $(2.0 \times 10^{-8})^2 =$ ___×___ **15.** $\sqrt{49 \times 10^{-18}} =$ ___×___

16. If B = A, evaluate: $\frac{B}{B-A}$ __________ **17.** Simplify: $\frac{25}{25-15}$ $\frac{5}{2}, 2\frac{1}{2}$, *or* 2.5

18. Circle equivalents of one-hundredth: $\frac{1}{10^2}$ 10^{-2} 0.02 200 0.001 $\frac{1}{100}$ 0.01 100

Enter the remaining coefficients that balance these chemical equations.

19. **4** NH_3 + ___7___ O_2 → ___4___ NO_2 + ___6___ H_2O

20. **12** NH_3 + ___15___ O_2 → ___12___ NO + ___18___ H_2O

Appendix 3

Demographics

As per a literature search, based on publications by Wilkerson (2008) and Habley, Bloom and Robbins (2012), demographic analyses are presented as being either personal characteristics (Supplement Tables 1-6) or environmental factors (Supplemental Tables 7-11 and Supplemental Figures 1-2).

The predictor variables have been divided into students' personal characteristics and those of the institution (*i.e.*, environmental factors) that the student has selected to attend as shown below.

Personal characteristics
- gender (male, female, or no response)
- ethnicity (white, Hispanic, black, Asian, and other)
- prior knowledge in chemistry (high school level: none, regular, pre-AP, AP/IB/Dual)
- mathematics requirement met (student has completed pre-calculus)
- entrance college (STEM major or not)
- family education (parents and/or grandparents have obtained a four-year degree (Yes, No, or Don't Know)

Environmental factors
- type of institution (HSI or Hispanic-emerging)
- student classification (freshman, sophomore, junior, or senior)
- whether students are employed on/off-campus (no or yes)
- hours worked hours range (0 hours, 1-10, 11-20, 21-39, and 40+)

Personal Characteristics
Almost two-thirds of the sample identified as female. A few students did not indicate a gender choice on the demographic survey so the analysis by gender includes 1586 students out of the study population of 1599. Statistical differences exist between MUST scores and course averages where males outperformed females (Supplemental Table 1) in both instances. Also, of interest is that the average course grade of the male student was at the B level and that of the female was at the C level.

Supplemental Table 1 Gender (n = 1586)

Gender	***n* (%)**	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
Female	1,029 (64.9%)	11.12 (4.68) (0.15)	77.72 (16.38) (0.51)
Male	557 (35.1%)	12.58 (4.72) (0.20)[a]	81.45 (15.69) (0.66) [b]
Average (*SD*) (*SE*)	**1586**	**11.87 (4.75)** (0.12)	**79.03 (16.24)** (0.41)

a,b Males significantly outperformed females on both the MUST and course average at $p < 0.05$ level.

Supplemental Table 2 presents data collected on the students' self-reported ethnicity. To present these data, average MUST scores were aligned from high to low in Supplemental Table 2. The MUST score averages except for the White and Hispanic categories (majority of the total population) were in alignment. Texas is classified as a majority-minority state (one of only five in the U.S., which is composed 50 states and one federal district). Population groups with fewer than 30 members (*e.g.*, Middle Eastern and Native American) were not evaluated. Twenty-two students did not report their ethnicity or reported that it was unknown. Statistical difference on course averages existed between Black and Asian students, and Hispanic students and White, non-Hispanic students. On the MUST, Asian students statistically outperformed all other groups as did Hispanic students and White students over mixed-race students, and Hispanics students and White, non-Hispanic students over Black students.

Supplemental Table 2 Ethnicity (n = 1562)

Ethnicity	***n (%)***	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
Asian	126 (8.1)	13.44 (4.60) (0.41)	81.63 (14.42) (1.28)
Hispanic	635 (40.7)	11.97 (4.96) (0.20)	78.82 (16.15) (0.64)
White, non-Hispanic	722 (46.2)	11.85 (4.44) (0.17)	79.01 (16.79) (0.62)
Mixed racial	33 (2.1)	9.52 (4.95) (0.86)	77.29 (17.21) (3.00)
Black	46 (2.9)	8.89 (4.77) (0.70)	73.54 (15.39) (2.27)

Prior knowledge of a particular academic subject has always been known to help students especially when enrolled in a course with a notable low-success rate (grades of D, F or withdrawal from the course). It is interesting that Chem II students, where all have supposedly successfully completed Chem I (and usually the semester before), can still have their performance ranked according to their high school chemistry background exposure. As can be seen in Supplemental Table 3, MUST scores and course averages still perfectly align with what highest high school chemistry course these students experienced. Students were asked to identify the most advanced high school chemistry course that they had completed. All but 17 students who responded had completed at least one year of high school chemistry. Of the 17 students who indicated no prior exposure to a high school chemistry course, about 25% were from out-of-state. Statistical differences exist between all MUST scores analyzed (*i.e.*, none vs. regular, regular vs. pre-AP, and pre-AP vs. AP/IB) but even though the higher the MUST score the better students performed in the course, the only statistical difference seen in nearby (*i.e.,* those closest to each other) course averages was between pre-AP and AP/IB students.

Supplemental Table 3 High school chemistry (n = 1586)

Highest High School Course	***n (%)***	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
None	17 (1.1)	7.53 (5.86) (1.42)	74.25 (17.59) (6.65)
Regular	385 (24.3)	10.12 (5.00) (0.25)	76.27 (16.57) (0.84)
Pre-AP	734 (46.3)	11.83 (4.36) (0.16)	78.08 (16.20) (0.60)
AP/IB	450 (28.4)	13.57 (4.42) (0.21)	83.00 (15.45) (0.73) [a]

[a] MUST scores and course averages are aligned but the only significant difference found between nearby groups was between Pre-AP and AP/IB course averages at $p < 0.05$ level.

At most institutions it is strongly suggested that students complete college algebra prior to enrolling in Chem I. Just as strongly suggested is that students should be enrolled in (or have completed) pre-calculus prior to entering Chem II. At some universities these suggestions are enforced and at others they are not. To determine whether or not students had the background necessary for success in Chem II, two questions were asked: (1) What is the most advanced mathematics course you have completed? and (2) What mathematics class are you currently enrolled? By understanding that different universities and different degree plans have different requirements and that some students who have completed the first semester of calculus have completed the mathematics course requirement for their degree plan, a decision was made to use completion of pre-calculus as the appropriate point to identify students who are prepared for Chem II enrollment. Students were also confused by how the questions were asked because they might not be currently enrolled in a mathematics course and may not have finished their degree requirement, and yet had completed pre-calculus. Also, another confusing point was where various universities have different titles for equivalent courses (*e.g.*, algebra vs. college algebra where one course might be more advanced than the other or probability & statistics might be a lower- or upper-level course). Nineteen students did not respond to either question. Statistical differences exist between MUST scores and final course averages indicating that completion of pre-calculus is warranted for enrollment in Chem II (Supplemental Table 4).

Supplemental Table 4 Mathematics course currently enrolled ($n = 1580$)

Pre-Calculus	***n (%)***	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
Not completed	632 (40.0)	7.53 (5.86) (0.23)	75.80 (16.51) (0.66)
Completed	948 (60.0)	10.12 (5.00) (0.16)[a]	81.17 (15.79) (0.51) [b]

[a,b] Students who entered Chem II with higher MUST score means completed the course with significantly higher averages at $p < 0.05$ level

Chem II is a course for science majors and as expected only 120 of 1567 (7.7%) who responded to the query identified their major in one of the non-STEM fields (Supplemental Table 5). The majority of the STEM majors were biology-degree seekers many expressing a desire to enter the health professions as a career. The entering MUST scores were statistically different but the final course averages were not statistically different even though STEM majors did outperform non-STEM majors.

Supplemental Table 5 STEM major ($n = 1567$)

Major	***n (%)***	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
Non-STEM	632 (40.0)	10.92 (4.91) (0.20)	77.27 (17.03) (0.68)
STEM	948 (60.0)	11.94 (4.73) (0.15) [a]	79.15 (16.11) (0.52)

[a] STEM major entered with significantly higher MUST mean at $p < 0.05$.

Family influences on education are discussed in the popular media and in educational settings. The TRIO definition of a person who qualifies as "first-generation" is based on whether or not a parent possesses a 4-year college or university degree. We expanded that definition to include not only parents who held a degree but, in a separate question, asked if one or more of their grandparents had a 4-year degree from a college or university. Our survey produced the information found in Supplemental Table 6. Eleven students did not report any information on their parents or grandparents as to whether they held a 4-year degree or not.

Supplemental Table 6 Influence of family members possessing degrees ($n = 1588$)

Grands	**Parents** [a]	***n* (%)**	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
Yes	Yes	587 (37.0)	12.75 (4.32) (0.18)	80.99 (15.54) (0.64)
N/DK	Yes	538 (33.9)	11.98 (4.82) (0.21	79.49 (15.63) (0.68)
No/DK	Unk/DK	16 (1.0)	11.38 (4.59) (1.15)	77.90 (19.93) (4.98)
No/DK	No	414 (26.1)	10.64 (4.95) (0.24)	76.10 (17.43) (0.86)
Yes	No	33 (2.1)	10.18 (4.88) (0.85)	73.45 (18.33) (3.19)

[a] Comparison: Yes (top two rows) to No parental groups (bottom two rows), students in the Yes group significantly higher at $p < 0.05$ level. Abbreviations: DK = Don't Know; Unk = unknown.

Over 35% ($n = 587$) of the students reported that both parents and grandparents have degrees and over 25% ($n = 414$) reported that no close relative (or they did not know) had a degree. There is almost a grade-level difference between students whose parents have a 4-year degree (top two groups) and those who do not (bottom two groups of Supplemental Table 6) supported by the fact that there exists a statistically significant difference between students whose parents hold a 4-year degree and those whose parents do not. The most important observation from Supplemental Table 6 is that prior knowledge as assessed by the MUST appears to be a significant factor in course performance as is the influence of close family members who possess degrees. Note that the MUST scores and course averages are in perfect alignment. This observation also adds credence to the assumption that what automaticity skills students have at the beginning of the semester influences their proficiency in the course.

Environmental Factors

The MUST scores and course averages for each institution are reported in Supplemental Table 7. Institutions in Table 9 are aligned by MUST scores, which almost align with the course averages. The last two rows of Supplemental Table 7 are Hispanic-serving institutions that are both public and of medium-sized undergraduate populations that comprise only about 12% of the total number of students evaluated. Students from the Hispanic-emerging institutions (top four rows) entered the semester with statistically higher MUST scores and finished the course with statistically higher averages at the grade of B vs. C average.

Supplemental Table 7 By institution data on MUST and course average (n = 1599)

	***n* (%)**	**Institution Type *n* (%)**	**MUST (*SD*) (*SE*)**	**Institution Type MUST (*SD*) (*SE*)**	**Course average (*SD*) (*SE*)**	**Course average (*SD*) (*SE*)**
Public R1, large	151 (9.4)	1414 (88.4)	13.62 (3.50) (0.28)	12.51 (4.41) (0.12) [a]	87.47 (9.80) (0.80)	79.67 (16.41) (0.44) [b]
Public R1, large	1004 (62.8)		12.88 (4.29) (0.14)		82.71 (10.23) (0.32)	
Private, small	156 (9.8)		11.76 (4.43) (0.35)		84.19 (8.76) (0.70)	
Public, medium Doc/PU	103 (6.4)		8.44 (4.42) (0.44)		78.55 (14.73) (1.45)	
Public, medium HSI	140 (8.8)	185 (11.6)	7.31 (4.44) (0.38)	6.80 (4.23) (0.31)	72.58 (16.41) (1.39)	73.26 (15.00) (1.10)
Public, medium HSI	45 (2.8)		5.22 (3.02) (0.45)		75.37 (9.21) (1.37)	
Average (*SD*) (*SE*)	**1599**		**11.85 (4.75) (0.12)**		**78.93 (16.38) (0.41)**	

[a,b] Comparison of students attending nonHSIs (top four rows) to students attending HSIs (bottom two rows): students at nonHSIs significantly outperformed students attending HSIs at $p < 0.05$ level.

When gender is separated by an environmental factor, student classification (Supplemental Table 8), MUST and course averages are in perfect alignment with freshmen, sophomores and juniors who entered Chem II with higher MUST averages also finishing the course with higher course averages; only senior students, who might have a sense of urgency, entered with the lowest MUST scores did not end with the lowest course average. Males statistically outperformed females in all classification averages except for the senior level (Supplemental Table 8). Freshmen statistically outperformed sophomores, juniors and seniors on both MUST and class averages. Sophomores' MUST scores were statistically different from juniors and seniors but their class average was only statistically different than juniors. Juniors' MUST scores are not statistically different but seniors did statistically outperform juniors as to their class averages.

Supplemental Table 8 Gender difference by classification on MUST (n = 1583)

Classification		MUST (*SD*) (*SE*)	MUST (*SD*) (*SE*)	Class Avg (*SD*) (*SE*)	Class Avg (*SD*) (*SE*)
Freshman Female	693	12.57 (4.02) (0.15)	13.14 (4.11) (0.13)	79.47 (16.45) (0.62)	81.06 (15.73) (0.48)
Freshman Male	380	14.18 (4.07) (0.21) [a]		83.97 (13.87) (0.71) [b]	
Sophomore Female	181	9.57 (4.97) (0.37)	10.38 (5.01) (0.30)	75.55 (15.16) (1.13)	76.49 (16.18) (0.95)
Sophomore Male	107	11.75 (4.81) (0.47)		78.09 (17.73) (1.64) [c]	
Junior Female	107	7.48 (3.94) (0.38)	7.97 (4.22) (0.37)	70.52 (17.22) (1.66)	70.88 (17.89) (1.43)
Junior Male	50	9.02 (4.64) (0.66)		71.64 (19.42) (2.75) [d]	
Senior Female	47	6.68 (4.44) (0.65)	6.98 (4.43) (0.55)	76.53 (12.53) (1.83)	76.18 (12.66) (1.57)
Senior Male	18	7.78 (4.41) (1.04)		75.27 (13.33) (3.14)	

[a,b,c,d] Freshman males significantly outperformed freshman females on the MUST and course average at $p < 0.05$ level, and sophomore and junior course averages were significantly higher at $p < 0.05$ level.

Fall 2018 students who lived in a dorm did better than those who reported to live off campus, but these students also came to their respective universities more prepared based on their MUST scores. The demographic question about living in university-supported housing was not asked in the Spring 2018, so the following data (Supplemental Table 9) are only representative of a subpopulation of n = 681 students from the Spring 2019 semester. Also, the two HSI universities have been eliminated since dorms on their campuses were not well populated and together they would only have contributed 1.5% for those who lived in a dorm. Students who live in university-supported housing entered with statistically higher MUST scores on the average (13.32 vs. 12.51) and completed the course with statistically higher overall course averages. It is possible that students who live on campus have access to more academic resources and it is well known that many dorms and Greek organizations are effective at keeping files of old tests easily accessed by current students. In all but one case (top row), students who lived in university-supported housing had higher MUST scores, and in all but one case (third row) students who lived in university-supported housing outperformed those who did not. Taking averaged MUST scores and course averages into consideration, students who live on campus outperformed those who did not.

Supplemental Table 9 Hispanic-emerging institutions and university-supported housing (n = 612)

	n (%)	MUST (*SD*) (*SE*) Supported	MUST (*SD*) (*SE*) Not Supported	Average (*SD*) (*SE*) Supported	Average (*SD*) (*SE*) Not Supported
Public R1, large	65 (8.9)	13.33 (3.88) (1.97)	13.54 (3.74) (0.46)	86.32 (7.58) (0.94)	.85 (10.97) (1.36)
Public R1, large	424 (57.9)	14.00 (4.08) (0.20)	13.17 (4.12) (0.20)	79.91 (16.73) (0.81)	.82 (17.63) (0.86)
Private, small	70 (9.6)	12.51 (4.32) (0.51)	10.60 (5.98) (0.71)	82.35 (10.91) (1.30)	.46 (6.57) (0.79)
Public, medium Doc/PU	53 (7.2)	9.27 (4.53) (0.62)	6.60 (3.82) (0.52)	82.95 (14.17) (1.95)	.41 (14.90) (2.05)
Average (*SD*) (*SE*)	**612**	**13.32 (4.33) (0.18)** [a]	**12.51 (4.53) (0.18)**	**81.16 (15.15) (0.61)** [b]	**78.29 (16.57) (0.67)**

a,b On the average, students who live in university-supported housing enter with significantly higher MUST scores and significantly outperformed students on course averages who live off campus at $p < 0.05$ level.

Student employment both on and off campus was explored and compared to the students who reported not to be employed (Supplemental Table 10). Of n = 1578 (21 students did not report), over 76% did not work; only 185 (11.6%) students report to work either on and/or off campus. Of these 185 students, 132 (8.4%) worked off campus and 53 (3.4%) worked on campus. The percentage of the Chem II students who do not work was consistent over both semesters. It is also of interest that the more students report to work the lower are their course averages. The lowest MUST average score

(6.37) was presented by the students who work more than 30 hours per week. It is also interesting to note that the subgroup of students who work for no more than 10 h/week had the highest course average of 81.11%, finishing the highest of any of the selected subgroups in Supplemental Table 10 (even higher than the students who do not work). In all subgroups, more students worked off than on campus. Three students in the 11-20 h group worked both on and off campus. In total, 127/185 (68.6%) students worked off campus with 87 (68.5%) students working from 1-20 h.

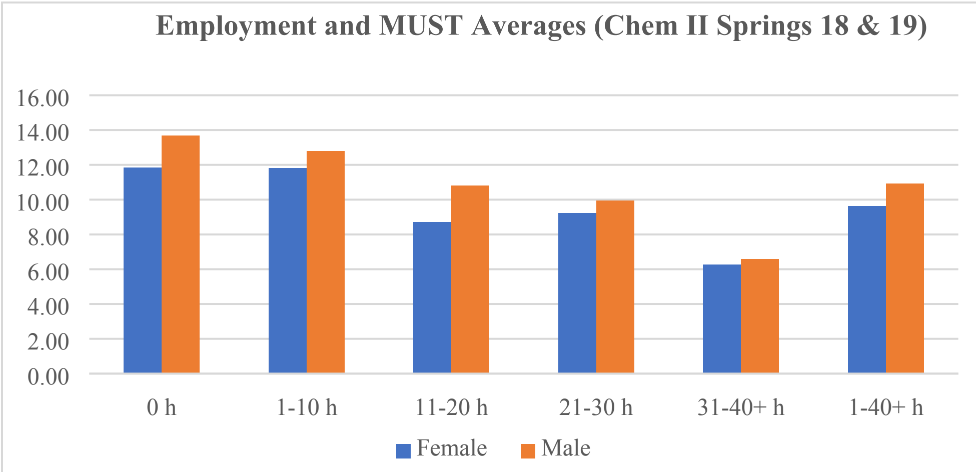
Supplemental Table 10 Employment

Hours Worked	***n* = 1578 (%)**	**MUST (*SD*) (*SE*)**	**Course Avg (*SD*) (*SE*)**
None	1,202 (76.2%)	12.50 (4.52) (0.13)	80.31 (15.80) (0.46)
1-10	126 (8.0%)	12.09 (4.45) (0.40)	81.11 (14.21) (1.27)
11-20	144 (9.1%)	9.53 (4.71) (0.39)	74.46 (16.24) (1.35)
21-30	71 (4.5%)	9.41 (4.60) (0.55)	68.96 (21.62) (2.57)
31- 40+	35 (2.2%)	6.37 (3.72) (0.63)	68.93 (15.02) (2.54)

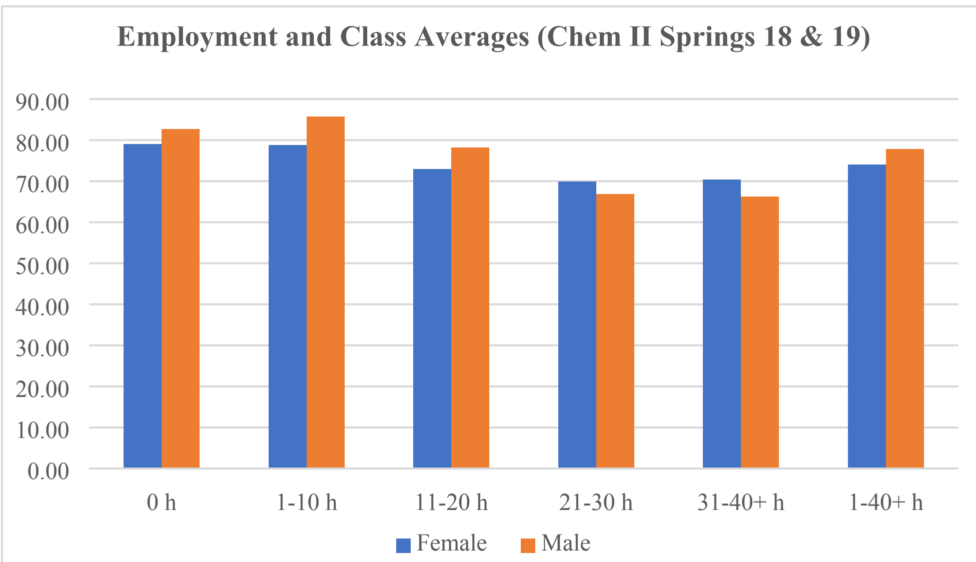
Breaking down employment by gender (Supplemental Table 11) supports that females who do not work have the highest MUST average score (11.85) and the highest overall course average (79.03%). However, in general the highest performing group overall was the males who work part-time for 1-10 h/week. In all MUST subcategories, males scored higher than the corresponding group of females. This trend held true for most of the course averages except for the indication that females who worked 21 or more hours/week outperformed males. Males who did not work or worked for 1-10 h/week performed at the grade level of B. All categories of females were at the grade level of C. Supplemental Figs. 1 (MUST) and 2 (class average) display the differences between the genders and their employment status as reported in Supplemental Table 11. On the average, both male and female students who have the privilege of not having to work, entered the course with greater prior knowledge and finished the course with higher course averages.

Supplemental Table 11 Employment by Gender (*n* = 1570)

Gender	**Employed**	***n***	**MUST (*SD*) (*SE*)**	**Course (*SD*) (*SE*)**
female *n* = 1017 (64.8%)	**Do Not Work**	**766**	**11.85 (4.47) (0.16)**	**79.03 (16.17) (0.58)**
	1-10 h/week	84	11.80 (4.47) (0.49)	78.80 (15.73) (1.72)
	11-20 h/week	94	8.70 (4.53) (0.47)	72.87 (15.61) (1.61)
	21-30 h/week	50	9.22 (4.40) (0.62)	69.86 (19.82) (2.80)
	31-40+ h/week	23	6.26 (3.58) (0.75)	70.38 (14.23) (2.97)
	Work	**251**	**9.62 (4.40) (0.28)**	**74.03 (16.36) (1.03)**
male *n* = 553 (35.2%)	**Do Not Work**	**432**	**13.68 (4.39) (0.21)**	**82.64 (14.81) (0.71)**
	1-10 h/week	41	12.80 (4.36) (0.68)	85.75 (9.15) (1.43)
	11-20 h/week	49	10.80 (4.77) (0.68)	78.20 (16.41) (2.34)
	21-30 h/week	19	9.95 (5.02) (1.15)	66.87 (25.71) (5.90)
	31-40+ h/week	12	6.58 (4.12) (1.19)	66.16 (16.71) (4.82)
	Work	**121**	**10.93 (4.63) (0.42)**	**77.79 (15.44) (1.40)**



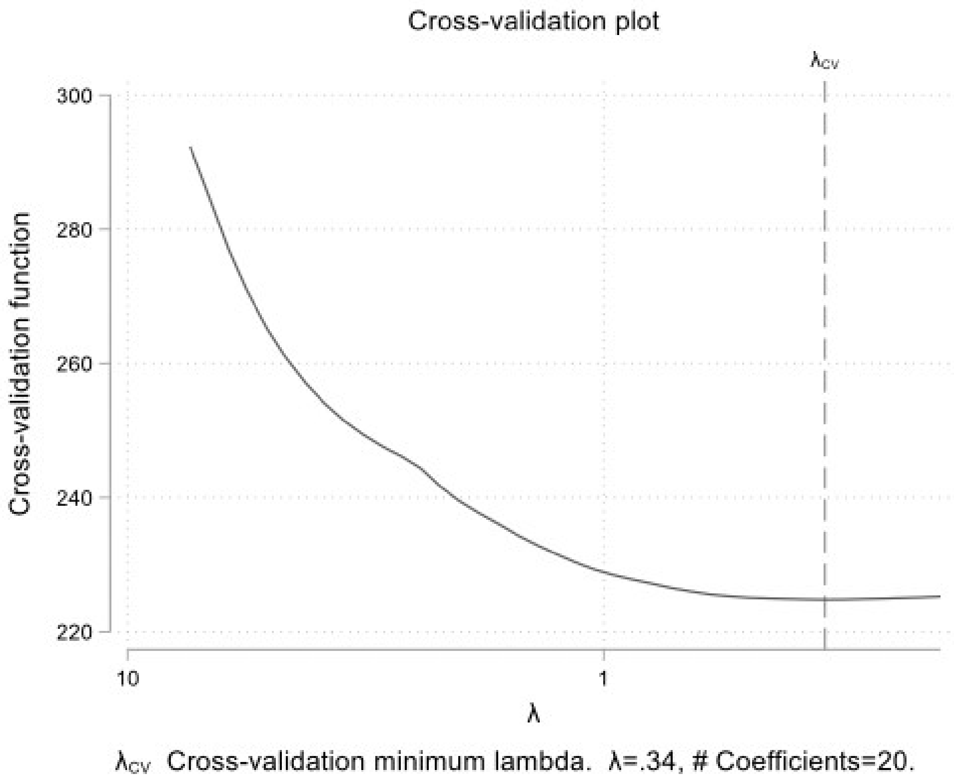
Supplemental Fig. 1 Gender differences in MUST scores and employment.

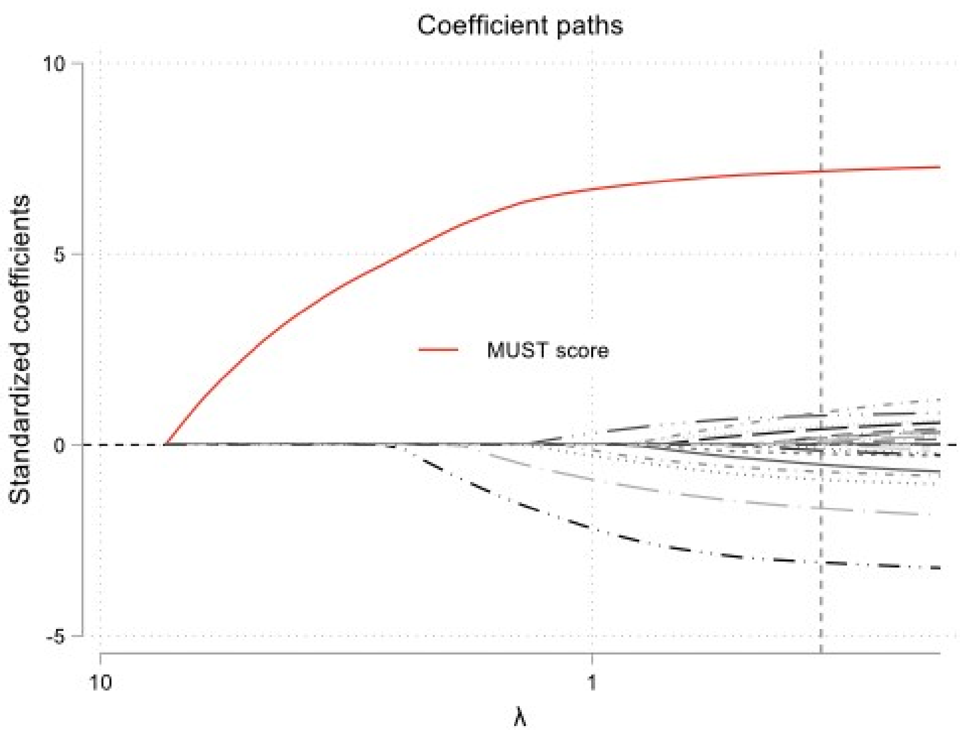


Supplemental Fig. 2 Gender differences in course averages and employment.

Appendix 4

Supplemental Statistical Description

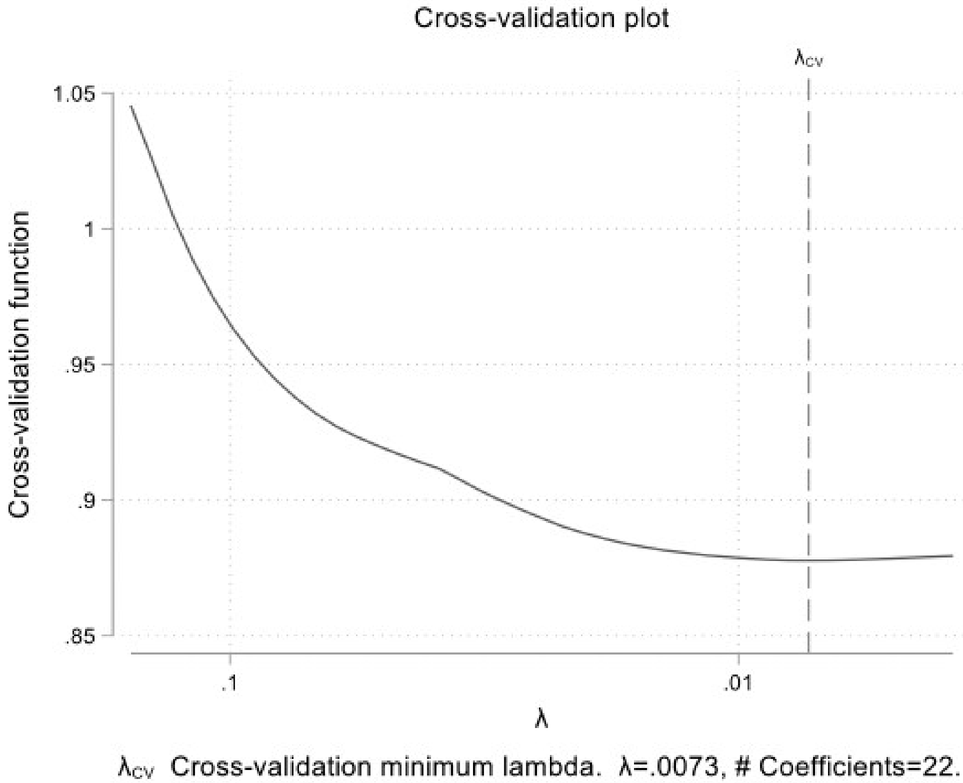


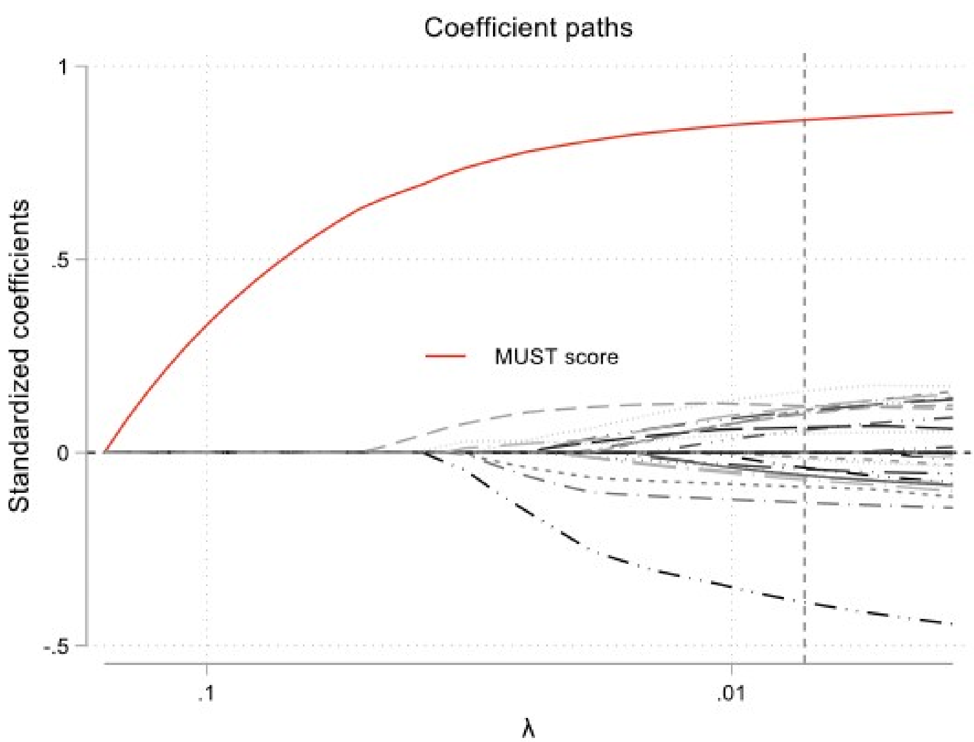


Supplemental Fig. 3 Minimum cross-validation lambda and linear model selection.

Supplemental Table 12 Linear regression coefficients on course average

MUST score	1.594
classification	
sophomore & senior	reference
freshman	0.144
junior	-4.063
gender	
male	reference
female	1.091
race/ethnicity	
Hispanic, Black, & Asian	reference
white	1.456
other	2.943
academic generation	
second generation	reference
don't know	1.823
first generation	-0.838
skipped generation	-3.550
third generation	1.735
hours worked	
0 hrs. & 40+ hrs. worked	reference
1-10 hrs.	1.197
11-29 hrs.	-3.151
30-39 hrs.	-10.04
high school chemistry	
none & pre-AP Chemistry	reference
high school Chemistry	-0.992
AP Chemistry	2.040
math requirement	
completed Pre-Calculus	reference
did not complete Pre-Calculus	-1.930
university	
Private, small & HSI, midsize 1	reference
R1 Large	-7.011
Public, large	3.631
HSI, midsize 2	9.962
R1 Large*	1.331
average of university coefficient	7.913
Constant	62.40
Observations	1005





Supplemental Fig. 4 Cross-validation plot.

Supplemental Table 13 Logistic regression coefficients on course success

MUST score	0.184
classification	
sophomore	reference
freshman	0.259
junior	-0.193
senior	-0.207
gender	
male	reference
female	-0.034
race/ethnicity	
Hispanic & Asian	reference
White	0.208
Black	-0.394
other	0.302
academic generation	
second generation & skipped generation	reference
don't know	0.307
first generation	-0.202
third generation	0.328
hours worked	
1-10 hrs. & 40+ hrs.	reference
0 hrs.	0.153
11-29 hrs.	-0.040
30-39 hrs.	-0.344
high school chemistry	
none & pre-AP Chemistry	reference
high school chemistry	-0.099
AP Chemistry	0.239
math requirement	
completed Pre-Calculus	reference
not completed Pre-Calculus	-0.120
university	
Public, large	reference
R1 Large	-0.806
Private, small	0.166
HSI, midsize 1	-0.443
HSI, midsize 2	0.705
R1 Large*	0.404
average of university coefficient	0.026
Constant	-0.539
Observations	1005

Supplement Table 14 Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) course average	1.000													
(2) MUST score	0.411	1.000												
(3) classification	-0.181	-0.396	1.000											
(4) gender	0.101	0.170	-0.013	1.000										
(5) race/ethnicity	0.002	-0.000	-0.005	-0.008	1.000									
(6) major	0.054	0.067	-0.145	0.037	0.025	1.000								
(7) version	0.005	-0.018	-0.052	-0.004	-0.032	-0.013	1.000							
(8) generation	0.056	0.080	-0.034	0.044	-0.113	-0.005	0.013	1.000						
(9) hours worked	-0.194	-0.286	0.357	-0.030	-0.003	-0.049	0.015	-0.089	1.000					
(10) high school chem	0.157	0.263	-0.210	0.005	0.019	0.074	-0.022	-0.018	-0.096	1.000				
(11) math requirement	0.105	0.191	-0.138	0.127	0.071	0.124	-0.130	0.012	-0.072	0.075	1.000			
(12) HSI	-0.123	-0.376	0.423	-0.009	0.134	0.015	-0.008	-0.140	0.365	-0.175	-0.005	1.000		
(13) university	0.073	-0.203	0.200	0.020	0.069	0.032	0.013	-0.203	0.266	-0.048	-0.003	0.476	1.000	
(14) semester	0.035	0.033	0.088	-0.027	-0.074	-0.118	0.022	-0.130	0.004	0.014	-0.255	0.079	0.087	1.000

Supplemental Figure 5. Scatter plot of individual MUST scores plotted against course averages by institution