Electronic Supplementary Material (ESI) for Chemistry Education Research and Practice.
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Appendix 1: MUST Student Versions (78 Version)

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.** $\frac{\frac{1}{4}}{\frac{1}{2}} =$ __________

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 <u>scientific notation</u>.

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

Appendix 1 Continued: MUST Student Versions (87 Version)

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

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

Write these values as their decimal equivalents:

9. $\dfrac{1}{8}=$ ______________________ **10.** $\dfrac{1}{20}=$ ______________________

11. If $\dfrac{P_1V_1}{T_1}=\dfrac{P_2V_2}{T_2}$ 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 <u>scientific notation</u>.

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

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

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: MUST Keys (78 Version)

Math-Up Skills Test (MUST)

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.** $78 \times 96 =$ $\underline{7488}$ (1 pt)

2. $(0.50 \times 10^{-6})(6.4 \times 10^{21}) =$ $\underline{3.2 \times 10^{15}}$ (1 pt)

3. $(2.50 \times 10^{-9})(3.0 \times 10^{17}) =$ $\underline{7.5 \times 10^{8}}$ (1 pt)

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

4. $\dfrac{140}{10,000} = \underline{0.014}$ (1 pt)

5. $47^0 = \underline{1}$ (1 pt)

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

Simplify: **7.** $\dfrac{10^5 \times 10^{23}}{10^{-1} \times 10^{-6}} = \underline{10^{35}}$ (1 pt)

8. $\dfrac{9.0 \times 10^{-18}}{2.0 \times 10^{-5}} = \underline{4.5 \times 10^{-13}}$ (1 pt)

Write these values as their decimal equivalents:

9. $\dfrac{1}{8} = \underline{0.125}$ (1 pt)

10. $\dfrac{1}{50} = \underline{0.02}$ (1 pt)

11. If $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ then solve for T_2, in symbols as one simple fraction: $T_2 = \dfrac{P_2V_2T_1}{P_1V_1}$ (1 pt)

Determine the base-10 log of: **12.** $1000 = \underline{3}$ (1 pt) and **13.** $0.001 = \underline{-3}$ (1 pt)

Solve questions **14** and **15** and write answers in <u>scientific notation</u>.

14. $(3.0 \times 10^{-7})^2 = \underline{9.0 \times 10^{-14}}$ (1 pt)

15. $\sqrt{64 \times 10^{-12}} = \underline{8.0 \times 10^{-6}}$ (1 pt)

16. If A = B, evaluate: $\dfrac{A}{A-B}$ $\underline{\text{undefined}}$ (1 pt)

17. Simplify: $\dfrac{25}{25-5}$ $\underline{\frac{5}{4}, 1\frac{1}{4}, \text{or } 1.25}$ (1 pt)

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

Enter the remaining coefficients that balance these chemical equations.

19. $\mathbf{4}\ NH_3 + \underline{\ 5\ }\ O_2 \rightarrow \underline{\ 4\ }\ NO + \underline{\ 6\ }\ H_2O$ (1 pt)

20. $\mathbf{12}\ NH_3 + \underline{\ 21\ }\ O_2 \rightarrow \underline{\ 12\ }\ NO_2 + \underline{\ 18\ }\ H_2O$ (1 pt)

Appendix 2 Continued: MUST Keys (87 Version)

Math-Up Skills Test (MUST)

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 $\underline{8352}$ (1 pt)

2. $(0.50 \times 10^{-4})(3.2 \times 10^{21}) = \underline{1.6 \times 10^{17}}$ (1 pt)

3. $(3.50 \times 10^{-9})(2.0 \times 10^{17}) = \underline{7.0 \times 10^{8}}$ (1 pt)

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

4. $\dfrac{24}{10,000} = \underline{0.0024}$ (1 pt) 5. $42^0 = \underline{1}$ (1 pt) 6. $\dfrac{\frac{1}{2}}{\frac{1}{3}} = \underline{1.5}$ (1 pt)

Simplify: **7.** $\dfrac{10^{7} \times 10^{-23}}{10^{-1} \times 10^{-6}} = \underline{10^{-9}}$ (1 pt) **8.** $\dfrac{7.0 \times 10^{-18}}{2.0 \times 10^{-7}} = \underline{3.5 \times 10^{-11}}$ (1 pt)

Write these values as their decimal equivalents:

9. $\dfrac{1}{8} = \underline{0.125}$ (1 pt) **10.** $\dfrac{1}{20} = \underline{0.05}$ (1 pt)

11. If $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ then solve for T_1, in symbols as one simple fraction: $T_1 = \dfrac{P_1V_1T_2}{P_2V_2}$ (1 pt)

Determine the base-10 log of: **12.** $10,000 = \underline{4}$ (1 pt) and **13.** $0.1 = \underline{-1}$ (1 pt)

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

14. $(2.0 \times 10^{-8})^2 = \underline{4.0 \times 10^{-16}}$ (1 pt) **15.** $\sqrt{49 \times 10^{-18}} = \underline{7.0 \times 10^{-9}}$ (1 pt)

16. If B = A, evaluate: $\dfrac{B}{B - A}$ $\underline{\text{undefined}}$ (1 pt) **17.** Simplify: $\dfrac{25}{25-15}$ $\underline{\tfrac{5}{2}, 2\tfrac{1}{2}, \text{or } 2.5}$ (1 pt)

18. Circle equivalents of one-hundredth: $\underline{\tfrac{1}{10^2}}$ $\underline{10^{-2}}$ 0.02 200 0.001 $\underline{\tfrac{1}{100}}$ $\underline{0.01}$ 100 (1 pt)

Enter the remaining coefficients that balance these chemical equations.

19. **4** NH_3 + $\underline{\quad 7 \quad}$ O_2 → $\underline{\quad 4 \quad}$ NO_2 + $\underline{\quad 6 \quad}$ H_2O (1 pt)

20. **12** NH_3 + $\underline{\quad 15 \quad}$ O_2 → $\underline{\quad 12 \quad}$ NO + $\underline{\quad 18 \quad}$ H_2O (1 pt)

Appendix 3: Demographic Analysis

The number of subjects varied for some of the demographics collected due to minor omissions in student surveys. General chemistry is a freshman-level course, which most students take on-sequence or in the fall semester. See Table 1 for descriptive data. Students who take this course as sophomores or above have possibly entered the university with college credit from high school enabling them due to credit hours accumulated to be classified higher than a freshman yet still in their first year of attendance, some may have delayed the course due to known deficiencies, some have unsuccessfully taken the course before, or some have delayed the course due to a change in major where general chemistry is now part of a required path. We do not know the reason why those sophomores and above were in the course, and the numbers vary a lot. For these reasons, differences by classification group was not analyzed as compared to their MUST score or their average. Note how the *SE* constantly increases as enrollment class elevates indicating that each classification above freshman level is less reflective of the population's mean due to the declining sub-population sizes.

Table 1 Classification descriptive data

Class	***n* = 1073**	**MUST (*SD*) (*SE*)**	**Course Average (*SD*) (*SE*)**
Freshman	771	11.17 (7.74) (0.17)	81.36 (12.59) (0.45)
Sophomore	199	7.70 (4.82) (0.34)	76.29 (13.53) (0.96)
Junior	83	8.35 (5.04) (0.55)	74.11 (13.09) (1.44)
Senior	20	10.05 (4.02) (0.90)	82.80 (10.79) (2.41)

The next phase of analysis explored other potential correlates within demographics (Tables 2-5). The female population in this study was larger than the male population by 18% (Table 2). This disparity, which is often seen, was exacerbated in our sample due to the existence of an engineering chemistry course at most of the institutions that students take instead of general chemistry. The engineering chemistry courses have a much larger male than female population. Data show that males entered Chem I with statistically higher MUST scores than females (Table 2, 2-tailed, *t*-test $p = 1.98$ E-5, effect size = 0.267). The effect size is small and was calculated with a Hedge's *g*, since there were unequal sample sizes. However, the final course averages showed no statistical difference at an alpha level of $p = 0.05$. The total population ($N = 1073$) is higher than the population in Table 2 because 9 students did not provide their gender identity on the demographic survey. These types of small discrepancies occur in almost every instance in the following tables due to the open nature of the demographic survey.

Table 2 Gender

Gender	***n* (%)**	**MUST (*SD*) (*SE*)**	**Course Average (*SD*) (*SE*)**
Female	627 (59.0%)	9.84 (4.87) (0.19)	79.98 (12.65) (0.51)
Male	437 (41.0%)	11.15 (4.94) (0.24)*	79.89 (13.43) (0.64)
Total	**1,064 (100.0%)**	**10.38 (4.93) (0.15)**	**79.94 (12.97) (0.40)**

*Male MUST score significantly higher at $p < 0.05$ level

Table 3 presents data for the ethnic categories chosen for this study shown in order of course average. The population is slightly smaller since two students opted not to disclose their ethnic background. The mixed group was defined as any student who indicated two or more ethnicities. The "other" group was composed of various small sample size ethnicities (*e.g.*,

Appendix 3 Continued: Demographic Analysis

Pacific Islanders, Native Americans, Asian Indians and Middle Easterners). Using an ANOVA, significant differences were found for the MUST ($p < 0.001$, $df = 5$) and course averages ($p < 0.001$, $df = 5$) for ethnic category groups. A Games-Howell post-hoc test was used to see where these differences in ethnic groups existed and does not assume equal variances and equal sample sizes. For the MUST, the Asian, White, and Other groups scored significantly higher than the Hispanic or Black groups at the $p < 0.05$ level (Hedge's effect sizes between two groups range from 0.933 to 0.799). Additionally, the Mixed group scored significantly higher than the Black group on the MUST ($p = 0.011$; Hedge's effect size = 0.548).

Table 3 Ethnicity

Ethnicity	***n* = 1071**	**MUST (*SD*) (*SE*)**	**Course Average (*SD*) (*SE*)**
Other	38	12.18 (5.40) (0.88)	82.76 (12.78) (2.07)
Asian	79	12.13 (4.88) (0.55)	83.31 (10.51) (1.18)
White	504	11.17 (4.65) (0.21)	82.55 (11.19) (0.50)
Mixed	93	10.08 (4.85) (0.50)	79.12 (14.00) (1.45)
Hispanic	292	9.04 (4.82) (0.28)	75.58 (13.95) (0.82)
Black	65	7.40 (4.89) (0.61)	73.90 (15.99) (1.98)

Games-Howell post-hoc significant results for MUST: Asian, White, Other > Black, Hispanic and Mixed > Black
Games-Howell post-hoc significant results for Average: Asian, White, Other > Black, Hispanic

Similar results were found for the course average in Table 3. The Asian, White and Other groups scored significantly higher than the Hispanic or Black groups on the course average at the $p < 0.05$ level (Hedge's effect sizes between two groups range from 0.590 to 0.567). It should be noted that these analyses use the average score for each group, individual high-scoring students were present in each group, such that while the averages were higher for the White group, an individual in that group might score much lower than another individual in the Hispanic group.

First-generation status is known to relate to success in completing a college degree (*e.g.*, Sirin, 2005), so we investigated the relationship between first-generation status and MUST score. On the demographic survey students were asked about their first-generation status. The National Science Foundation's TRiO program's definition was used as the qualifier: Did your parents complete a college or university degree? TRiO is not an acronym. Instead, it stands for the number (3) of the original of the U.S. federal programs to increase representation of economically disadvantaged students in higher education, which presently consists of more than three programs even though it has retained the name. Students in this study were also asked if their grandparents had completed a degree, because a number of this generation has significant grandparent influence in their daily lives (Monserud, 2011). Again, it is very interesting how MUST scores provided at the first of a semester somewhat parallel the final course average. Students who were members of families where both generations possessed degrees finished Chem I with the highest overall average and also entered the course with the highest MUST scores (see Table 4). Students from families where only the parents possessed a degree completed the course with a B average, like the top performing group, and had the second highest MUST score. Students from families where no parental or guardian had completed a college education (or the status was unknown) completed the course with the lowest MUST scores and course averages.

Appendix 3 Continued: Demographic Analysis

Using an ANOVA significant differences were found in the MUST ($p < 0.001$, $df = 4$) and course average ($p < 0.001$, $df = 4$) by college graduation of the grandparents or parents. Using a Games-Howell post-hoc test to account for differences in sample size and variance, students who had both grandparents and parents graduate from college scored significantly higher than all other groups on the MUST (Hedge's effect sizes between two groups range from 0.551 to 0.228). On the course averages, the Games-Howell post-hoc showed that first-generation students, for whom neither the grandparents or parents graduated from college, were significantly lower than students who had parents or both parents and grandparents who graduated from college. The Hedge's effect size was 0.533 between first-generation students and those with both degreed parents and grandparents, while the effect size between the course averages of first-generation students and those with degreed parents was 0.302. These are medium to small effect sizes.

Table 4 Family degreed status ($N = 1073$)

Family Group				
Parents	**Grandparents**	***n* (%)**	**MUST (*SD*) (*SE*)**	**Course Average (*SD*) (*SE*)**
Yes	Yes	420 (39.1%)	11.43 (5.00) (0.24)	82.67 (11.48) (0.56)
Yes	No	217 (20.2%)	10.30 (4.86) (0.33)	80.07 (12.68) (0.86)
**Yes/Unknown*	*Yes/Unknown*	131 (12.2%)	9.82 (4.49) (0.39)	79.05 (14.78) (1.29)
No	No	270 (25.2%)	9.22 (4.80) (0.29)	76.09 (13.53) (0.82)
Unknown	Unknown	35 (3.3%)	8.69 (4.57) (0.78)	77.19 (13.98) (2.36)

[*] One generation held a degree but the other generation was unknown to the student.

Games-Howell post-hoc significant results for MUST: Degrees both parents and grandparents > all others

Games-Howell post-hoc significant results for Average: Degrees both parents and grandparents or Degree parents > no family degrees

Table 5 compares gender and hours of employment per week. Females were compared to males based on whether they were employed or not. There was no statistical difference between females who <u>do not</u> work and males who <u>do not</u> work on course averages (81.32 versus 81.81), using a two-tailed *t*-test giving $p = 0.518$. There was a statistical difference on the MUST scores, where the male MUST score of 11.81 was statistically higher than the 10.23 score for the females using a two-tailed *t*-test giving $p < 0.001$, with Hedges' effect size = 0.332. This difference is not surprising since Table 3 showed that males overall had a higher MUST scores than females. There were no statistical differences between females who work and males who work on either the course average or the MUST scores.

Next working females were compared to non-working females and likewise for males. Females who do not work have significantly better MUST scores than those who worked (2-tailed *t*-test $p < 0.001$, Hedges' effect size = 1.079) and significantly better course averages (2-tailed *t*-test $p < 0.001$, Hedges' effect size = 0.486). The effect size is large for the MUST scores, but medium for the course average. Like results were found for the males. Males who do not work have significantly better MUST scores than those who worked (2-tailed *t*-test $p < 0.001$, Hedges' effect size = 0.479) and significantly better course averages (2-tailed *t*-test $p < 0.001$, Hedges' effect size = 0.513) both are medium effect sizes. It appears that being employed could be negatively impacting students' course averages by a letter grade on average. Note the steady decline of course averages and MUST scores as the time spent working increases. However, it should be noted that males who work 1-10 h/week have course averages along with MUST scores that show improvement over the men who did not work. This is similar to the findings of

Appendix 3 Continued: Demographic Analysis

Dundes and Marx (2006). In all cases the MUST score for the males was higher than for the females of the corresponding group. The one subgroup exception where females' course average was higher than the male counterparts was for the females who worked 11-19 h/week, which probably influenced the overall average of working females who scored just higher than working males by 0.23 points.

Table 5 Employment (*n* = 1059)

Gender	Employment	MUST (*SD*) (*SE*)	CourseAverage (*SD*) (*SE*)
female *n* = 625 (59.0%)	**Do Not Work (*n* = 485)**	**10.23 (4.75) (0.22)**$^{+}$	**81.34 (11.90) (0.54)** $^{+}$
	1-10 h/week	9.61 (4.64) (0.72)	80.10 (13.48) (2.10)
	11-19 h/week	8.82 (5.07) (0.72)	76.71 (12.46) (1.76)
	20-29 h/week	8.56 (5.22) (0.87)	71.39 (13.48) (2.25)
	30-40+ h/week	4.00 (3.16) (0.88)	65.57 (17.10) (4.74)
	Work (*n* = 140)	**8.54 (5.03) (0.43)**	**75.30 (14.08) (1.19)**
male *n* = 434 (41.0%)	**Do Not Work (*n* = 315)**	**11.81 (4.76) (0.27)**$^{*+}$	**81.81 (12.45) (0.70)** $^{+}$
	1-10 h/week	12.57 (5.07) (1.11)	86.00 (9.88) (2.16)
	11-19 h/week	9.17 (4.58) (0.67)	74.86 (15.61) (2.30)
	20-29 h/week	9.53 (5.35) (0.98)	72.26 (14.38) (2.63)
	30-40+ h/week	7.05 (4.06) (0.88)	68.62 (11.95) (2.61)
	Work (*n* = 119)	**9.49 (5.02) (0.46)**	**75.07 (14.73) (1.36)**

*$p < 0.05$ Males MUST score significantly higher than females who do not work, but no difference in course averages was apparent

$^{+}p < 0.05$ non-working students of both genders had significantly higher MUST scores and course averages than their working counterparts.

Summary

There were significant impacts of the student demographics on the MUST scores based on gender and on employment. Males did have significantly higher MUST scores than females overall; when split by employment, males who did not work still significantly outperformed non-working females on the MUST. Similar gender effects were found by Mason and Mittag (2001). There were no differences in MUST scores between working males and females. When considering females who work to those who do not and males in a similar manner, non-working members of both genders scored higher on the MUST than the same gender who work, as was similar to the results from Lammers, Onwuegbuzie, and Slate (2001). For ethnicity and graduation of parents or grandparents, complementary to previous literature, produced significant differences in both the MUST and course averages. The most disadvantaged groups were the Hispanic and Black groups (typical URMs in the USA), as is consistent with other studies (*e.g.,* Mason and Verdel, 2001). The least favored graduation group was the students who had neither grandparents nor parents graduate from college; these findings mirror those of others (*e.g*., Sirin, 2005). While these findings were not unexpected, the research questions for this study involved investigating an instrument that could be quickly and cheaply used with little effort to identify at-risk students in first-semester general chemistry.

Appendix 4: Predicting Course Averages: First Ineffective Attempts

The correlation between the course average and the MUST score was 0.536 with $p < 0.001$, indicating a significant correlation. Some researcher's might test the ability of the MUST to predict a course average by using the MUST score to group students. A mean course average was calculated for each group (Fig. 1). For example, all students with a MUST score of 20 were used to find a mean course average for that group. This method was similar to that used by Stone, Shaner, and Fendrick (2018) and reduces the data to 21 points. The question is how effective is the prediction using the regression from Fig. 1 with its 21 data points. Fig. 1 represents an overfitting of the data, where the residual variation has been extracted and the function is too closely fit to a limited set of data (James *et al.*, 2013). There is a better way to analyze the data by fitting the entire data set.

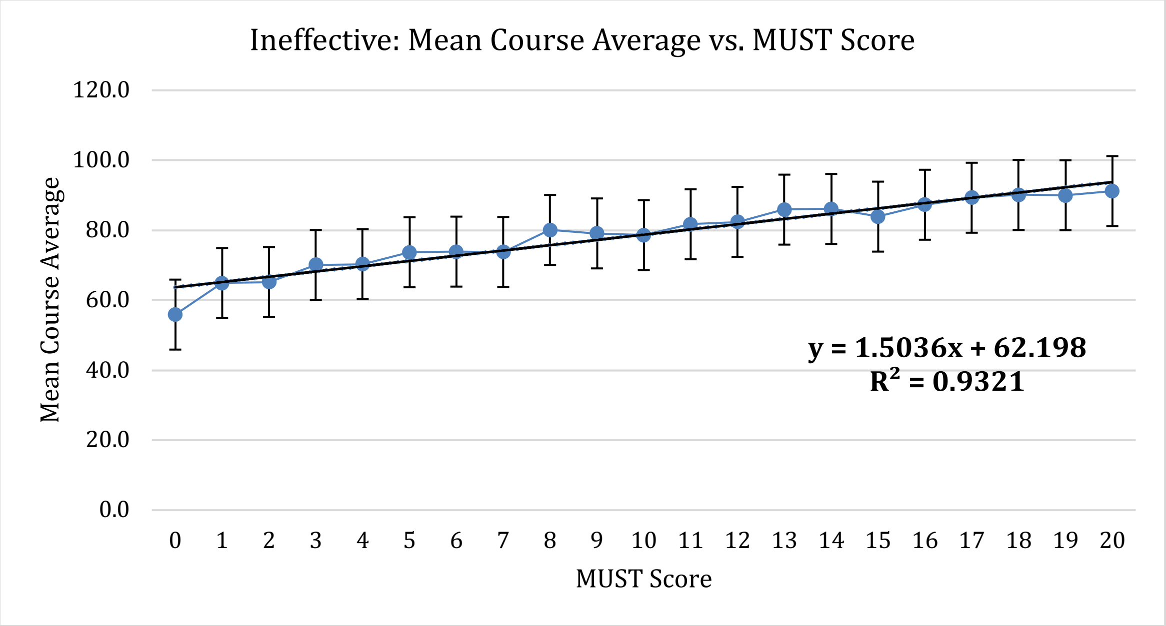

Fig. 1 Relationship between MUST scores and Chem I course grades

Fig. 2 shows a plot of all of the data ($N = 1073$) collected. While this plot does show all of the data, the noise with the changing standard deviation and frequency for each MUST score affects the regression. There is too much variability in the data in Fig. 2 for a meaningful linear relationship. For example, the average course grade for the eight students who made a 0 on the MUST (see the dots on the y-axis) is 55.90%, but the regression equation gives the y-intercept as 65.189. This indicates that the course average is not described fully in a linear relationship by the MUST alone, so this is not adequate to accurately predict course averages. We were still searching for a better way to predict the course average.

Appendix 4 Continued: Predicting Course Averages: First Ineffective Attempts

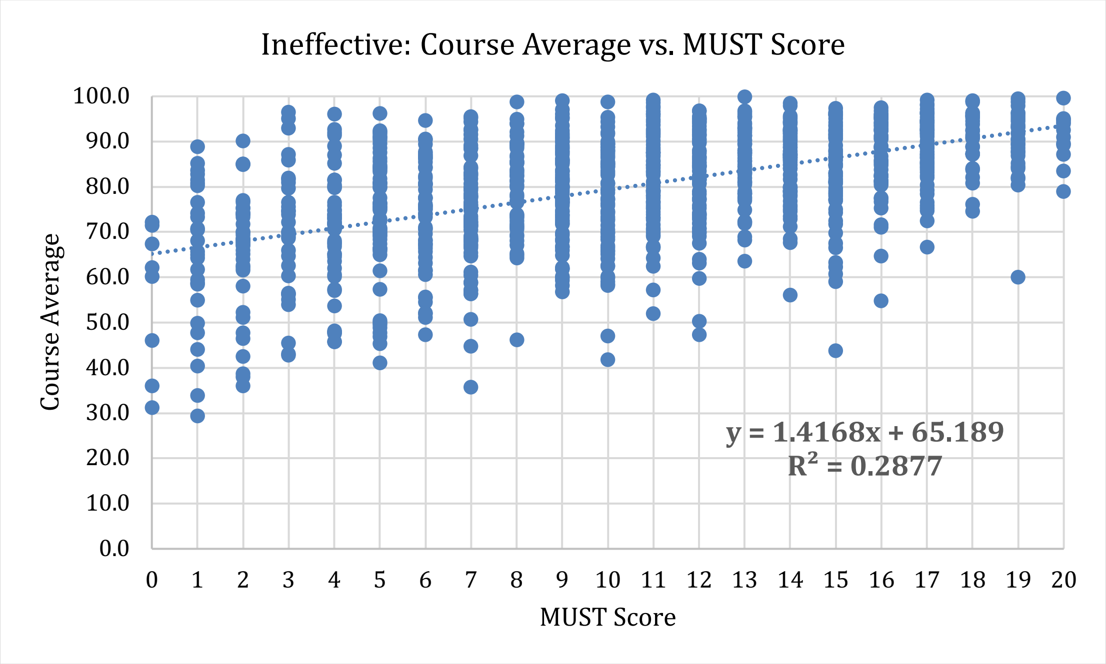

Fig. 2 Relationship between MUST scores (*N* = 1073) and Chem I course grades.

Appendix 5: Linear Regression with all features

Note: For a categorical variable with k categories will only have (k - 1) coefficients, with the missing variable accounted in the intercept (school 1, freshman, etc.). Included in the intercept for this model are the following categories for the categorical variables: school1, freshman, no response gender, ethnicity Asian, dual major, don't know parents graduation, don't know grandparents graduation, not employed, worked zero hours, and used version 78.

	Estimate	Std. error	*t*-value	*p*-value
(Intercept)	66.1432	6.5281	10.132	1.41E-22*
school 2	-4.3808	2.7488	-1.5937	0.1115
school 3	-2.5512	1.4375	-1.7748	0.0764
school 4	-2.9252	2.1937	-1.3334	0.1828
school 5	-1.4613	1.5926	-0.9176	0.3591
school 6	4.1143	1.6973	2.424	0.0156*
class JR	2.2381	1.7633	1.2693	0.2048
class SO	0.6943	1.0796	0.6431	0.5204
class SR	5.5569	2.6927	2.0636	0.0394*
gender female	4.8381	4.6984	1.0297	0.3035
gender male	3.874	4.7273	0.8195	0.4128
ethnicity Black	-5.0589	2.1155	-2.3914	0.0171*
ethnicity Hispanic	-4.4672	1.546	-2.8896	0.004*
ethnicity Mixed	-1.1831	1.8997	-0.6228	0.5336
ethnicity Other	-3.4682	2.3942	-1.4486	0.1479
ethnicity White	-1.1408	1.524	-0.7485	0.4544
major med	5.322	2.5357	2.0988	0.0362*
major other	2.593	2.8216	0.919	0.3584
major STEM	2.9688	2.539	1.1693	0.2427
grandparent not college grad	-1.6867	1.3424	-1.2565	0.2094
grandparent college grad	-0.7456	1.3136	-0.5676	0.5705
parent not college grad	-2.741	3.2722	-0.8376	0.4025
parent college grad	-0.3543	3.1652	-0.1119	0.9109
employed on campus	-1.6834	2.4008	-0.7012	0.4834
employed off campus	-1.7054	2.3537	-0.7246	0.469
hours worked 1-10	2.5875	2.6926	0.961	0.3369
hours worked 11-19	-1.1345	2.4784	-0.4578	0.6473
hours worked 20-29	-5.7161	2.8268	-2.0221	0.0436
hours worked 30-39	-3.6991	4.1289	-0.8959	0.3706
hours worked 40+	-15.41	4.6578	-3.3084	0.001*
version 87	-0.1878	0.7874	-0.2385	0.8115
MUST score	1.1176	0.0941	11.8792	9.97E-30*

**p*-value < 0.05

Appendix 6: LASSO Regression coefficients for modeling course average

Note: For a categorical variable with k categories will only have (k - 1) coefficients, with the missing variable accounted in the intercept (school 1, freshman, etc.). Included in the intercept for this model are the following categories for the categorical variables: school1, freshman, no response gender, ethnicity Asian, dual major, don't know parents graduation, don't know grandparents graduation, not employed, worked zero hours, and used version 78.

	Estimate
(Intercept)	69.3116
school 2	-1.3896
school 3	0
school 4	0
school 5	0
school 6	4.8346
class JR	0
class SO	0
class SR	3.0867
gender female	0.2625
gender male	0
ethnicity Black	-1.3886
ethnicity Hispanic	-2.7164
ethnicity Mixed	0
ethnicity Other	0
ethnicity White	0.0687
major med	1.9629
major other	0
major STEM	0
grandparent not college grad	-0.9243
grandparent college grad	0
parent not college grad	-1.8036
parent college grad	0
employed on campus	0
employed off campus	-1.5033
hours worked 1-10	1.0308
hours worked 11-19	-0.1483
hours worked 20-29	-4.116
hours worked 30-39	-0.2839
hours worked 40+	-11.1646
version 87	0
MUST score	1.0733

Appendix 7: Logistic Regression with all features

Note: For a categorical variable with k categories will only have (k - 1) coefficients, with the missing variable accounted in the intercept (school 1, freshman, etc.). Included in the intercept for this model are the following categories for the categorical variables: school1, freshman, no response gender, ethnicity Asian, dual major, don't know parents graduation, don't know grandparents graduation, not employed, worked zero hours, and used version 78.

	Estimate	Std. error	*z*-value	*p*-value
(Intercept)	-1.0171	1.6199	-0.6279	0.5301
school 2	-0.6077	0.6728	-0.9033	0.3664
school 3	-0.4117	0.4494	-0.9161	0.3596
school 4	-0.9068	0.5584	-1.624	0.1044
school 5	-0.2498	0.4562	-0.5477	0.5839
school 6	1.3107	0.5843	2.2432	0.0249*
class JR	1.3322	0.5483	2.4296	0.0151*
class SO	0.4347	0.2922	1.4879	0.1368
class SR	1.5871	1.1144	1.4241	0.1544
gender female	0.728	1.0142	0.7178	0.4729
gender male	0.4795	1.0276	0.4667	0.6407
ethnicity Black	-0.8688	0.6514	-1.3336	0.1823
ethnicity Hispanic	-1.1158	0.5226	-2.1352	0.0327*
ethnicity Mixed	-0.5852	0.6123	-0.9557	0.3392
ethnicity Other	-1.3751	0.715	-1.9231	0.0545
ethnicity White	-0.3708	0.5394	-0.6874	0.4918
major med	1.142	0.6153	1.8558	0.0635
major other	0.6575	0.6976	0.9425	0.3459
major STEM	0.8175	0.6103	1.3395	0.1804
grandparent not college grad	-0.1838	0.3708	-0.4956	0.6202
grandparent college grad	0.3563	0.3829	0.9304	0.3522
parent not college grad	-0.4842	0.9074	-0.5336	0.5936
parent college grad	-0.1053	0.8714	-0.1208	0.9038
employed on campus	-0.5696	0.6076	-0.9374	0.3486
employed off campus	-0.535	0.6061	-0.8827	0.3774
hours worked 1-10	1.2594	0.8115	1.552	0.1207
hours worked 11-19	0.2266	0.66	0.3434	0.7313
hours worked 20-29	-0.4352	0.7023	-0.6198	0.5354
hours worked 30-39	-0.2553	1.0317	-0.2475	0.8045
hours worked 40+	-16.2453	528.2598	-0.0308	0.9755
version 87	0.208	0.2297	0.9051	0.3654
MUST score	0.2012	0.03	6.7035	2.04E-11*

**p*-value < 0.05

Appendix 8: **LASSO Regression coefficients for modeling success/failure**

Note: For a categorical variable with k categories will only have (k - 1) coefficients, with the missing variable accounted in the intercept (school 1, freshman, etc.). Included in the intercept for this model are the following categories for the categorical variables: school1, freshman, no response gender, ethnicity Asian, dual major, don't know parents graduation, don't know grandparents graduation, not employed, worked zero hours, and used version 78.

	Estimate
(Intercept)	-0.2423
school 2	-0.0888
school 3	0
school 4	-0.4305
school 5	0
school 6	1.1751
class JR	0.5509
class SO	0.0288
class SR	0.5858
gender female	0.0803
gender male	0
ethnicity Black	0
ethnicity Hispanic	-0.5503
ethnicity Mixed	0
ethnicity Other	-0.4894
ethnicity White	0.0914
major med	0.2466
major other	0
major STEM	0
grandparent not college grad	-0.1386
grandparent college grad	0.2993
parent not college grad	-0.2292
parent college grad	0
employed on campus	-0.0295
employed off campus	-0.1171
hours worked 1-10	0.4302
hours worked 11-19	0
hours worked 20-29	-0.487
hours worked 30-39	0
hours worked 40+	-3.0628
version 87	0
MUST score	0.1762

Appendix 9: Demographic Survey to Use With our Coefficients or Code

Name (last): ____ **(first):** ____________________________________

Demographic Information

INSTRUCTION: Circle one option from each or fill-in the blank provided.

1. Classification: Freshman Sophomore Junior Senior

2. Gender: Male Female

3. Ethnicity:
   White Black/African Am Hispanic/Latino Asian
   Other: ______________________________
   Mixed: ___________________ + __________________ + ___________________

4. Major:
   a. STEM (Science: non-Medical, Technology (all), Engineering (all), Mathematics)

   b. Medical (all)

   c. Non-STEM (any and all)

   d. Dual (at least one STEM and at least one non-STEM)

5. Did any of your grandparents complete a college or university degree?
   Yes No Don't Know

6. Did any of your parents/guardians complete a college or university degree?
   Yes No Don't Know

7. Do you work on campus? Yes No

8. Do you work off campus? Yes No

9. For how many total hours (h) per week are you paid?
   0 h 1-10 h 11-19 h 20-29 h 30-39 h 40+ h