Texas NSA Project

Numeracy Skills Needed for QR Success in General Chemistry

Deborah Walker, PhD & Diana Mason, PhD, ACSF

The National Numeracy Network
11:30-12:00, Wells Hall A118
October 13, 2018

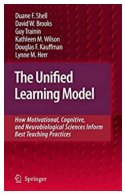
Abstract

Success in first-semester general chemistry, a known 'high-risk' course, is being studied as a continuing research endeavor by the NSA Texas team to evaluate college-ready students' number sense ability needed for course success. Results indicate that lacking basic arithmetical skills (Cohen's *d* = 2.22) may be hampering students' numeracy ability more than the highly touted algebraic skill set (Cohen's *d* = 0.206) usually associated with success in CHEM I. Informed decisions indicate that basic arithmetic skills have deteriorated or at a minimum become dormant over years possibly due to dependency on e-calculating devices. Without foundational arithmetic skills, advancing QL/QR abilities may be limited. Presented will be the results of a two-year study of *n* = 3,265 students from eight higher education institutions in Texas based on data gathered from the MUST (arithmetic) and DAT (algebra) diagnostic instruments.

Unified Learning Model (ULM)

(Shell et al., 2010)

- Memory –
  - Working: where connections are made
  - Long-term: learned information
- Motivation –
  - Directs WM towards learning
- Prior knowledge –
  - Determines ease, speed, and efficiency of processing
- Engagement (meaningful!) –
  - Shared responsibility



Shared Responsibility

Where is the breakdown?

Shared Responsibility

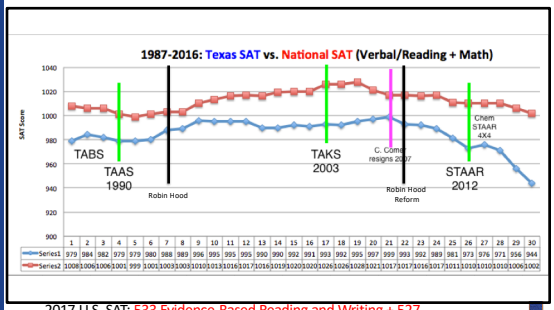
Shared Responsibility

What can QR/QL understanding do for Meaningful Engagement?

The Gap

30-years of SAT: Texas v. USA

(Max score = 1600)



2017 U.S. SAT: 533 Evidence-Based Reading and Writing + 527 Math = **1060 Total** (up 58 points)

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Proficiency

"A real phenomenon we're now seeing is that we have more and **more students with a diploma**, ***but*** we also know — look at test scores over the last few years — we're **not** graduating **more** students who are **proficient**."

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(All with IRB Approval)

- **Diana Mason, UNT (retired)**
- **Collaborating researchers**
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  - Ben Jang, TAMU-C, Regents Professor
  - Blain Mamiya, TSU Lecturer
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  - Adrian Villalta-Cerdas, Sam Houston State Assistant Professor
  - Deborah Rush Walker, UT Austin Lecturer
  - Rebecca Weber, UNT Lecturer
  - Vickie Williamson, TAMU Instructional Professor

NSA Team Members' Institutions

Fall 2017-Fall 2018	Undergrad Enrollment (Pop Rank)	Hispanic Emerging > 15%	Hispanic Serving > 25%	*Minority-Serving > 50%
TAMU (R1)	50,707 (#1)			
UT (R1: pre-ID'd at-risk grp)	40,492 (#2)			
TSU (R2)	34,180 (#5)			
UNT (R1)	31,405 (#6)		23.4%	36.0%
TAMU-C (R2)	12,490		19.7%	40.9%
Sam Houston (R3)	8,031		21.9%	40.1%
UHCL	5,798			
TAMU-SA	5,417			
ACU (private)	4,427			

Added for Fall 2018: no data to date!

***MSI = 50%+ URMs**

Goal: Get all 37 Texas Public Universities on board!

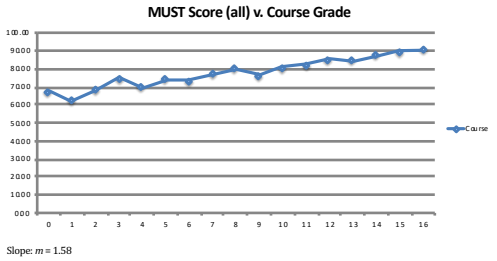
Protocol

- Research plan
  - Year 1 (Pilot): Effect(s) of calculator (*n* = 2,117)
    - MUST
  - Year 2: Effect(s) of automaticity (*n* = 3,266)
    - MUST
    - DAT
  - Year 3: Effect(s) of automaticity (*n* = 643 +)
    - MUST
    - QR
    - Non-cognitive: Higher Education Expectations
- Drop instrument with smaller effect size
- Add new instruments each iteration

AY 1: Pilot Study

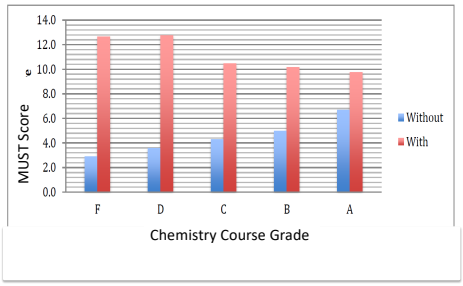
MUST (no calculator) & Course grade

r = .451 (WITHOUT) and *r* = .402 (WITH)



Mean (WITHOUT) 7.36/16 = 46.0%
Mean (WITH) = 12.19/16 = 76.2%

Are Students Dependent on Calculators?



Positive slope without calculators; negative slope with!

AY 2: Prior Knowledge Focus

High School Chemistry

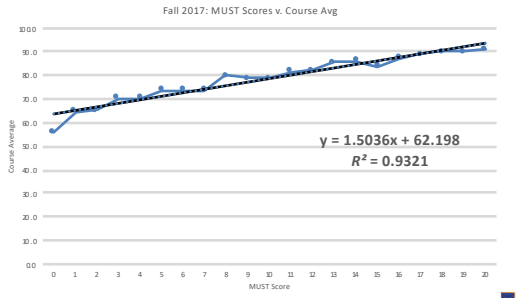
HS Chem	*n* = 1,064	Course Avg (*SD*)	MUST (*SD*)	DAT (*SD*)	PreCal +
AP/IB	240	84.6 (*11.3*)	12.2 (*4.6*)	16.7 (*3.2*)	166/240 = 69.2%
Pre-AP	536	79.8 (*12.9*)	10.4 (*4.8*)	15.7 (*3.4*)	357/536 = 66.6%
Regular	276	76.3 (*13.8*)	8.9 (*4.9*)	14.7 (*3.6*)	138/276 = 50.0%
None	12	71.2 (*13.8*)	6.2 (*3.5*)	13.1 (*5.2*)	6/12 = 50.0%

Mathematics

Grade	Cal I or II *n* (avg %)	PreCal *n* (avg %)	Col Alg *n* (avg %)	Prob/Stat *n* (avg %)	None/Dev *n* (avg %)	No Report *n* (avg %)
A	103 (93.5%)	138 (94.1%)	48 (92.5%)	8 (92.7%)	10 (91.9%)	1 (89.3%)
B	99 (84.6%)	117 (83.7%)	79 (83.5%)	14 (84.6%)	17 (83.7%)	1 (81.6%)
C	51 (73.9%)	90 (73.7%)	81 (73.2%)	17 (73.7%)	17 (74.5%)	1 (73.6%)
D	12 (64.5%)	35 (63.3%)	43 (64.3%)	7 (64.3%)	9 (63.3%)	3 (65.7%)
F	11 (53.5%)	15 (50.5%)	28 (49.9%)	9 (42.0%)	9 (44.1%)	0
Total	276 (83.8%)	395 (82.0%)	279 (75.8%)	55 (72.8%)	62 (73.8%)	6 (65.7%)

Majority of students (276 + 395/1,073 = 62.5%) currently are enrolled in pre-cal or higher (groups A and B) and have a B average.

Fall 2017 MUST vs. Course Average



Most-missed Example Problems

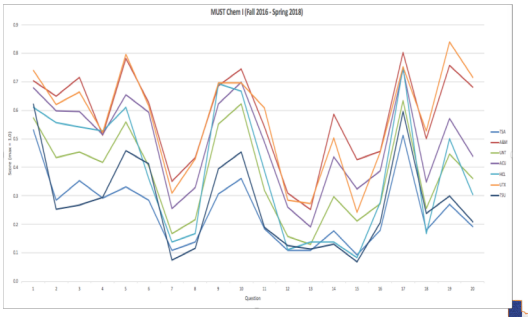
(< 30% correct)

- Division with exponential notation:
  $\frac{9.0\times10^{-18}}{2.0\times10^{-5}}$ $\frac{10^{5}\times10^{23}}{10^{-1}\times10^{-6}}$
- Logs: Determine the base-10 log of: 1000 = ____ and 0.001 = ____
- Power of 10 square root: $\sqrt{64\times10^{-12}}$
- *Division by 0: If A = B, evaluate $\frac{A}{A-B}$

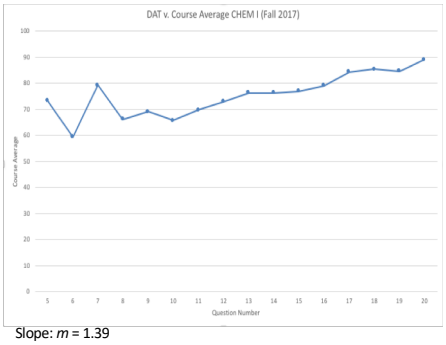
None of 20 questions > 70% correct!

*New question for fall 2017

MUST (by institution)

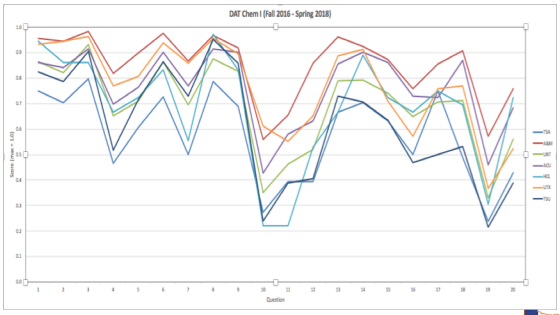


DAT: Algebra Skills

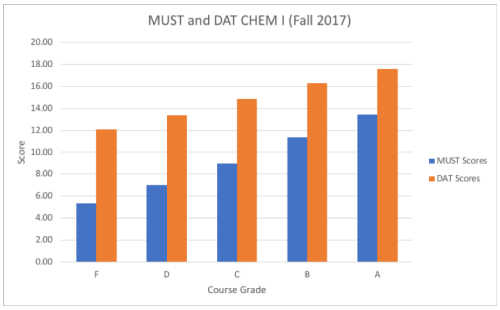


Slope: $m = 1.39$

DAT (by institution)

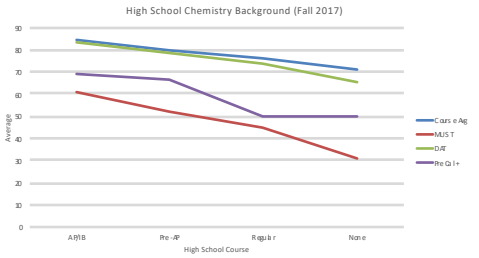


Letter Grades



Identify the potential D/F students at the beginning of semester (or before) and provide them with the HIPs needed to improve their math-sense!

Prior Knowledge



Correlations & Effect Sizes

Course average (*SD*) = 76.75 (*15.56*)

Correlation (*r*): MUST:DAT = 0.700

n = 3.266	Max = 20 points	Correlation to Avg	R^2
MUST	7.75 = 38.75%	0.398	0.158
DAT	14.71 = 73.55%	0.324	0.105

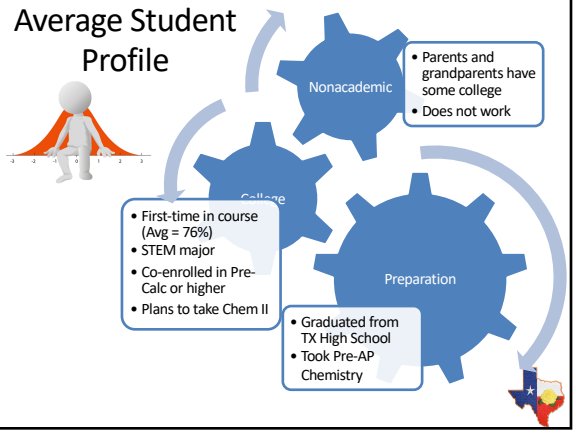
Effect Size DAT : Course Avg = .206 [small]
indicating 50% chance of predicting average from DAT (algebra skills)

Effect Size MUST : Course Avg = 2.22 [huge]
indicating that there is a **80% chance** (or greater) of predicting course average from MUST (arithmetic skills)

Predictability of MUST Ranges (Fall 2017)

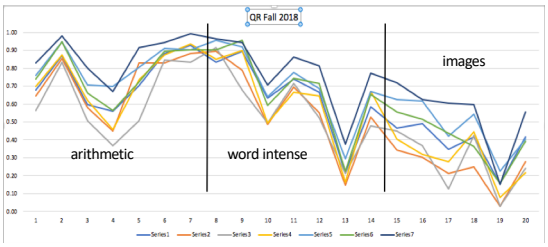
MUST Range	*n*	Average (*SD*) (*SE*)	*n* with Average < 69.5% (% in MUST range)
Above average (> 12)	392	87.05 (8.85) (0.45)	12 (3.06%)
Average (8-12)	347	80.42 (10.90) (0.59)	45 (12.97%)
Below average (< 8)	334	70.85 (13.71) (0.75)	123 (36.82%)
Total	**1073**	**79.86 (13.02) (0.40)**	**180 (16.78%)**

Average Student Profile



AY 3: QR Introduction

Quantitative Reasoning (Fall 2018)



N = 643; correlation between MUST and QR = 0.658 (a little lower than with the DAT, *r* = 0.700); mean on MUST = 6.69; mean on QR = 12.09

Most Missed QR Arithmetic

0.8% means:

a. 8 out of 100 b. 0.8 c. 8.0 d. 0.08 e. $\frac{0.8}{100}$

Most Missed QR Word Problems

Let $U_A = \frac{r}{1-U_B}$. Solve this equation for U_B in terms of U_A and r.

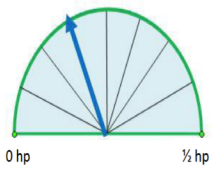
a. $\frac{r-U_A}{r}$ b. $\frac{r-U_A}{U_A}$ c. $\frac{1-r}{U_A}$ d. $\frac{U_A-r}{r}$ e. $\frac{U_A-r}{U_A}$

In a certain company there are 3 times as many men working as women. What is the fraction of employees that are female?

a. $\frac{1}{3}$ b. $\frac{3}{10}$ c. $\frac{2}{3}$ d. $\frac{3}{4}$ e. $\frac{1}{4}$

Near Most Missed QR with Image

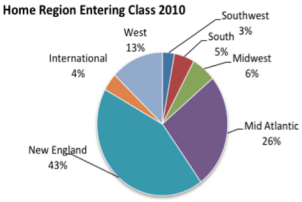
The attached gauge shows the power output of a small motor up to one-half horsepower (hp). Express the power output shown by the gauge in horsepower (hp), simplifying any fractions. Assume that the sections are evenly spaced.



a. 2/9 b. 3/4 c. 3/8 d. 3/16 e. 4/3

Most Missed QR with Image

19. Choose the answer that best describes a comparison between the number of students from the Midwest and the number of International students.



a. The number of students from the Midwest is 2% more than the number of International students.
b. Twice as many students came from the Midwest as from International locations.
c. There are 25 more students from the Midwest than from International locations.
d. The number of International students is 25% more than the number from the Midwest.
e. The number of students from the Midwest is 50% more than the number of International students.

MUST vs QR: Institution

	n	MUST	QR
Small, HSI	71	2.23	9.75
Middle, Pub	76	5.26	10.20
Large, HSI	79	5.61	10.97
Small, HSI	84	6.36	11.68
Large, Pub	115	6.96	12.27
Large, Pub	112	8.08	13.13
Small, Private	106	10.00	14.87
Total	**643**	**6.69**	**12.09**

*MUST and QR scores are in alignment.

MUST vs QR: Gender

	n	MUST*	QR*
Female	308	4.96 (3.78)	10.68 (3.10)
Male	221	7.56 (4.92)	12.73 (3.40)
Total	**531**	**6.05**	**11.54**

MUST and QR scores are in alignment.
*Males statistically outperformed females on MUST and QR.

MUST vs QR: Ethnicity

	n	MUST*	QR*
Non-Hispanic	328 (62.4%)	6.81 (4.57)	12.07 (3.40)
Hispanic	198 (38.6%)	4.67 (3.82)	10.66 (3.12)
Total	**526**	**6.01**	**11.54**

MUST and QR scores are in alignment.
Non-Hispanics statistically outperformed Hispanics on MUST and QR.

MUST vs QR: Race

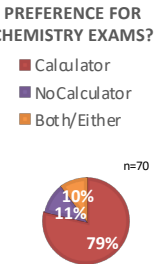
	n (%)	MUST	QR
Asian/PI	49 (9.4%)	7.82 (4.75)	12.06 (3.45)
Mixed	9 (1.7%)	6.33 (4.47)	*11.22 (3.31)
White	313 (60.3%)	6.05 (4.41)	*11.86 (3.24)
Black	78 (15.0%)	5.99 (4.28)	11.00 (3.43)
Native Am/Alaskan	10 (1.9%)	5.70 (4.17)	10.90 (4.41)
Other	60 (11.6%)	4.58 (3.95)	10.42 (3.40)
Total	**519**	**6.03**	**11.55**

*MUST and QR scores are almost in alignment.

HIGH IMPACT PRACTICES (HIP)

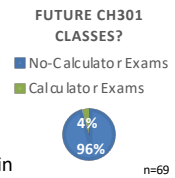
Your Preference?

- No Calculator:
  - "I prefer the chemistry exams ***without*** a calculator… With a calculator, you could take a ***long time*** because you can use the answer and try ***to work backwards***. Without a calculator, you either know it or you don't.
- Calculator:
  - "I prefer exams with a calculator because I know the process however sometimes ***I get nervous*** or anxious during exams which hinders my mathematical capabilities and ***the calculator makes sure*** that doesn't get the better of me and that ***my grade remains intact***."



Recommend to Future Students?

- No Calculator:
  - "Honestly, I think not using a calculator has ***better prepared*** me for CH302."
- Calculator:
  - "The ***reason I failed*** my first two exams in CH301 was because I struggled greatly with ***estimating***. I don't feel like that's fair because I knew the chemistry and this is a chemistry course."



Next Steps

- Determine the degree to which QR skills relate to success in general chemistry
- Implement HIPs
  - Re-awaken numeracy skills
  - Support QR skill development
- Spread the word
  - Numeracy skills are declining in college students

Summary

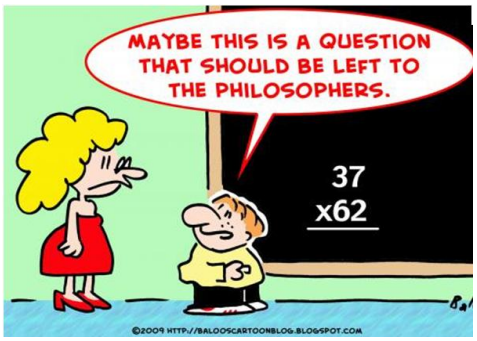
- Numeracy skills are "low-hanging fruit"
  - MUST identifies at-risk students taking chemistry
  - Number sense is linked to chemistry course success
- Quantitative Reasoning warrants further study
  - Numeracy skills may be limited by reasoning skills
  - Chemistry success may improve as both QR and numeracy skills improve

Acknowledgments

Many thanks to the Networking for Science Advancement (NSA) Team for contributing to this statewide project!

Also, thanks are extended to Eric Gaze for getting the NSA Team started on QL/QR research line and sharing his problems from QLRA with us, and to Peter Brown for allowing us to select problems from his "Number Sense" research collection of problems that can be solved without e-devices!

Questions?



Diagnostic Instruments

- Math-Up Skills Test (MUST): arithmetic skills
  - Hartman, JA. R.; Nelson, E. A. *Automaticity in Computation and Student Success in Introductory Physical Science Courses.* Cornell University Library. arXiv:1608.05006v2 [physics.ed-ph]
    - Quiz: http://bit.ly/1HyamPc **(Named: MUST)**
  - Authors
    - Hartman (U.S. Naval Academy)
    - Nelson, Chemistry instructor (multi-institutions)
  - Highly reliable (*KR-20* = 0.863)
- Diagnostic Algebra Test (DAT)
  - Cooper, C. I., Pearson, P. T. (2012). A Genetically Optimized Predictive System for Success in General Chemistry Using a Diagnostic Algebra Test. *Journal of Science Education and Technology*, 21 (1), 197-205.

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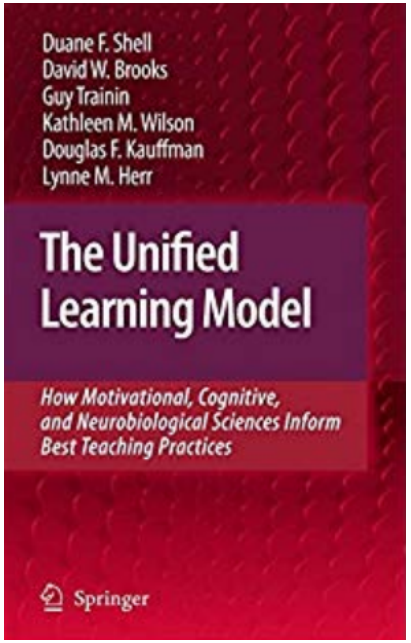

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Where is the breakdown?

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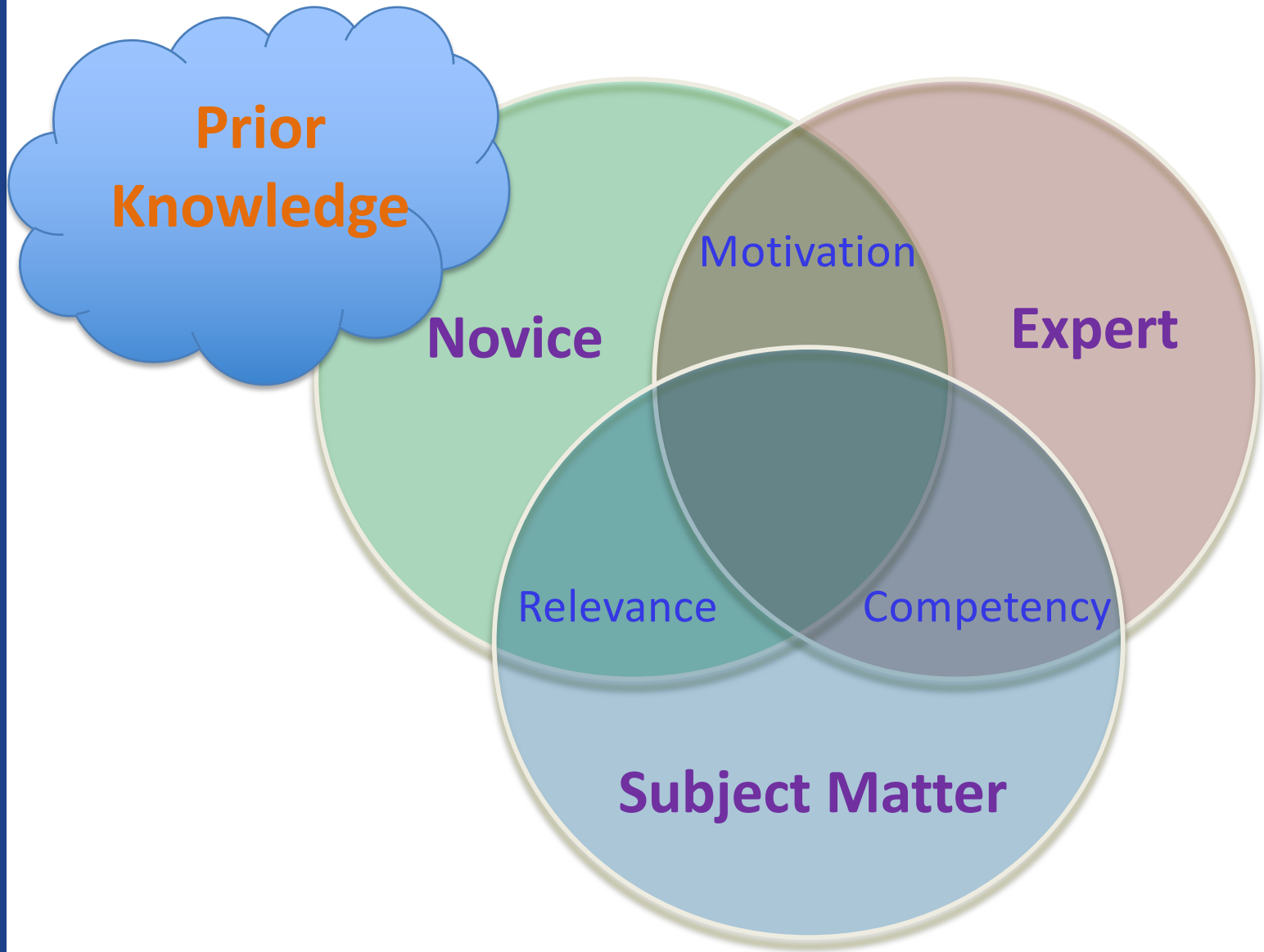

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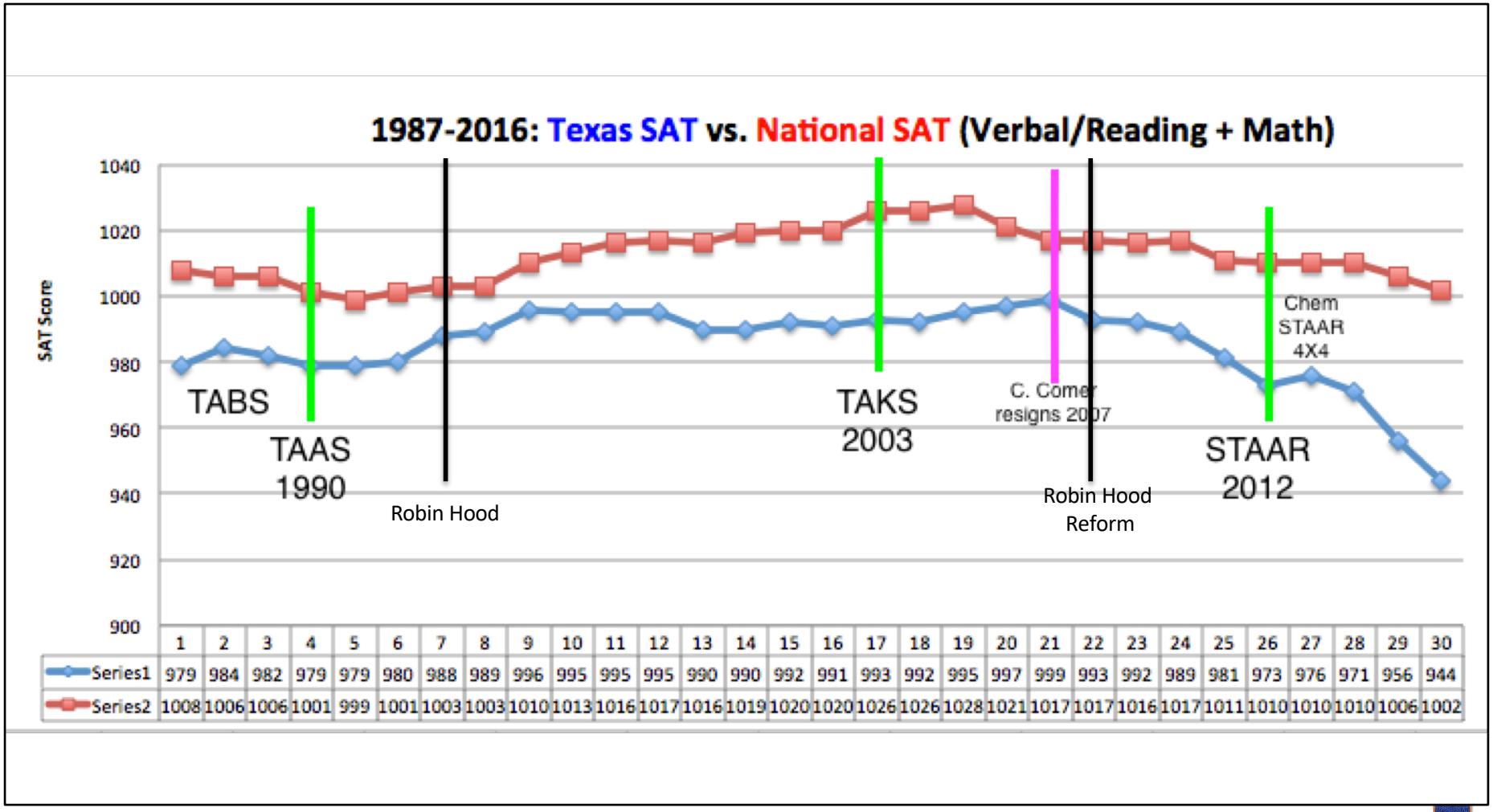
30-years of SAT: Texas v. USA

(Max score = 1600)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series1	979	984	982	979	979	980	988	989	996	995	995	995	990	990	992	991	993	992	995	997	999	993	992	989	981	973	976	971	956	944
Series2	1008	1006	1006	1001	999	1001	1003	1003	1010	1013	1016	1017	1016	1019	1020	1020	1026	1026	1028	1021	1017	1017	1016	1017	1011	1010	1010	1010	1006	1002

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TSU (R2)	34,180 (#5)			
UNT (R1)	31,405 (#6)		23.4%	36.0%
TAMU-C (R2)	12,490		19.7%	40.9%
Sam Houston (R3)	8,031		21.9%	40.1%
UHCL	5,798			
TAMU-SA	5,417			
ACU (private)	4,427			

Added for Fall 2018: no data to date!

***MSI = 50%+ URMs**

Goal: Get all 37 Texas Public Universities on board!

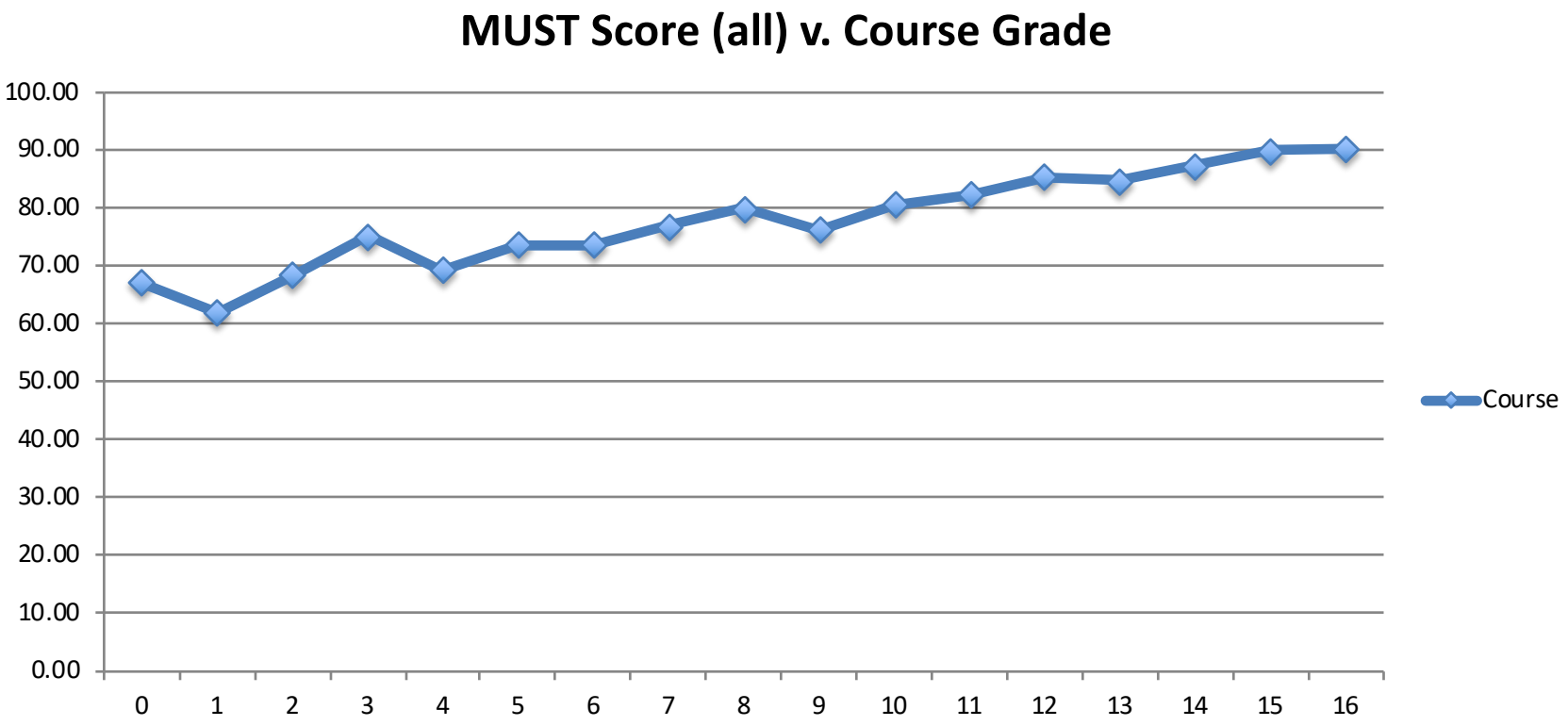
Protocol

- Research plan
  - Year 1 (Pilot): Effect(s) of calculator (*n* = 2,117)
    - MUST
  - Year 2: Effect(s) of automaticity (*n* = 3,266)
    - MUST
    - DAT
  - Year 3: Effect(s) of automaticity (*n* = 643 +)
    - MUST
    - QR
    - Non-cognitive: Higher Education Expectations
- Drop instrument with smaller effect size
- Add new instruments each iteration

AY 1: Pilot Study

MUST (no calculator) & Course grade

r = .451 (WITHOUT) and *r* = .402 (WITH)

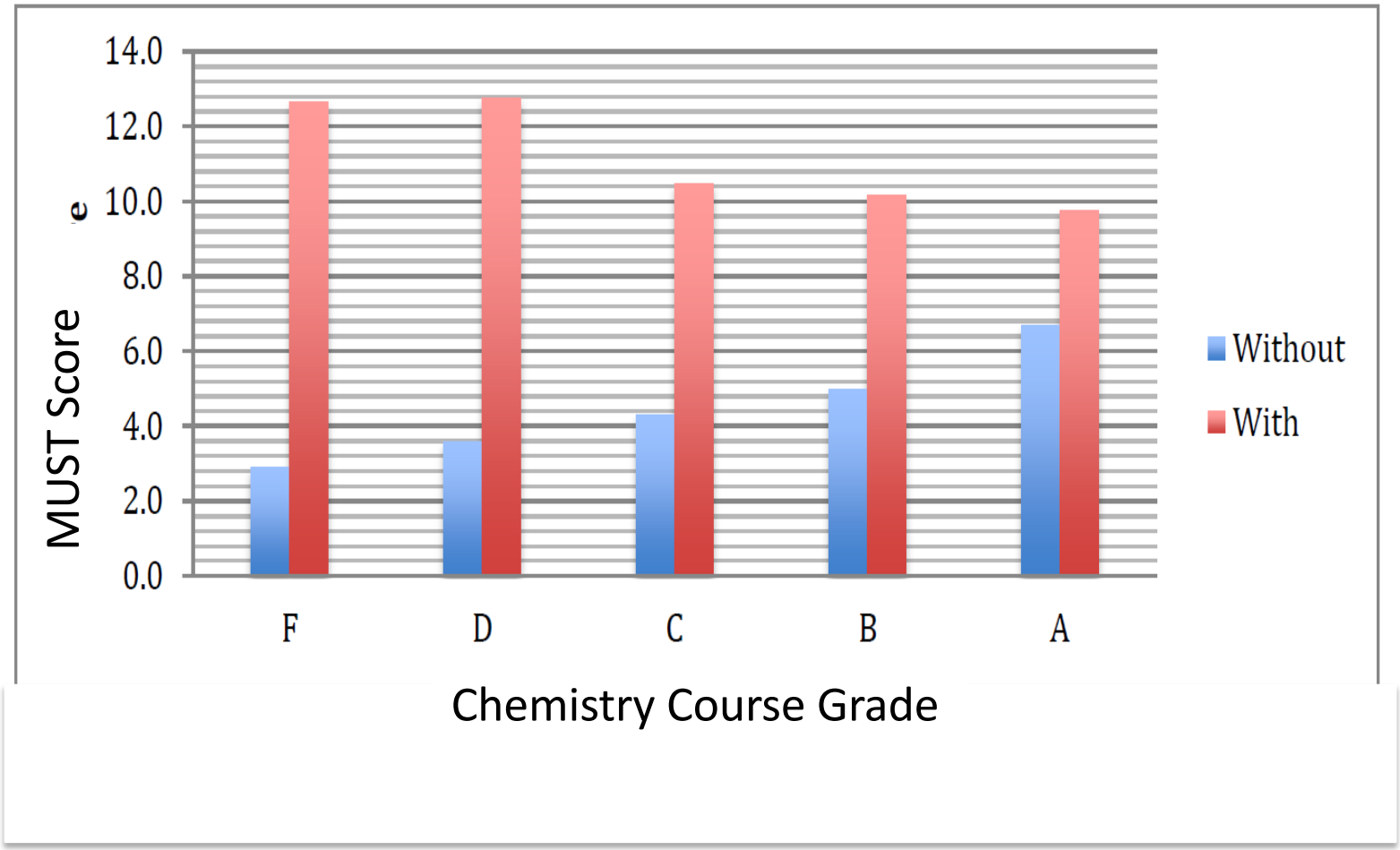


Slope: *m* = 1.58

Mean (WITHOUT) 7.36/16 = 46.0%

Mean (WITH) = 12.19/16 = 76.2%

Are Students Dependent on Calculators?



Positive slope without calculators; negative slope with!

AY 2: Prior Knowledge Focus

High School Chemistry

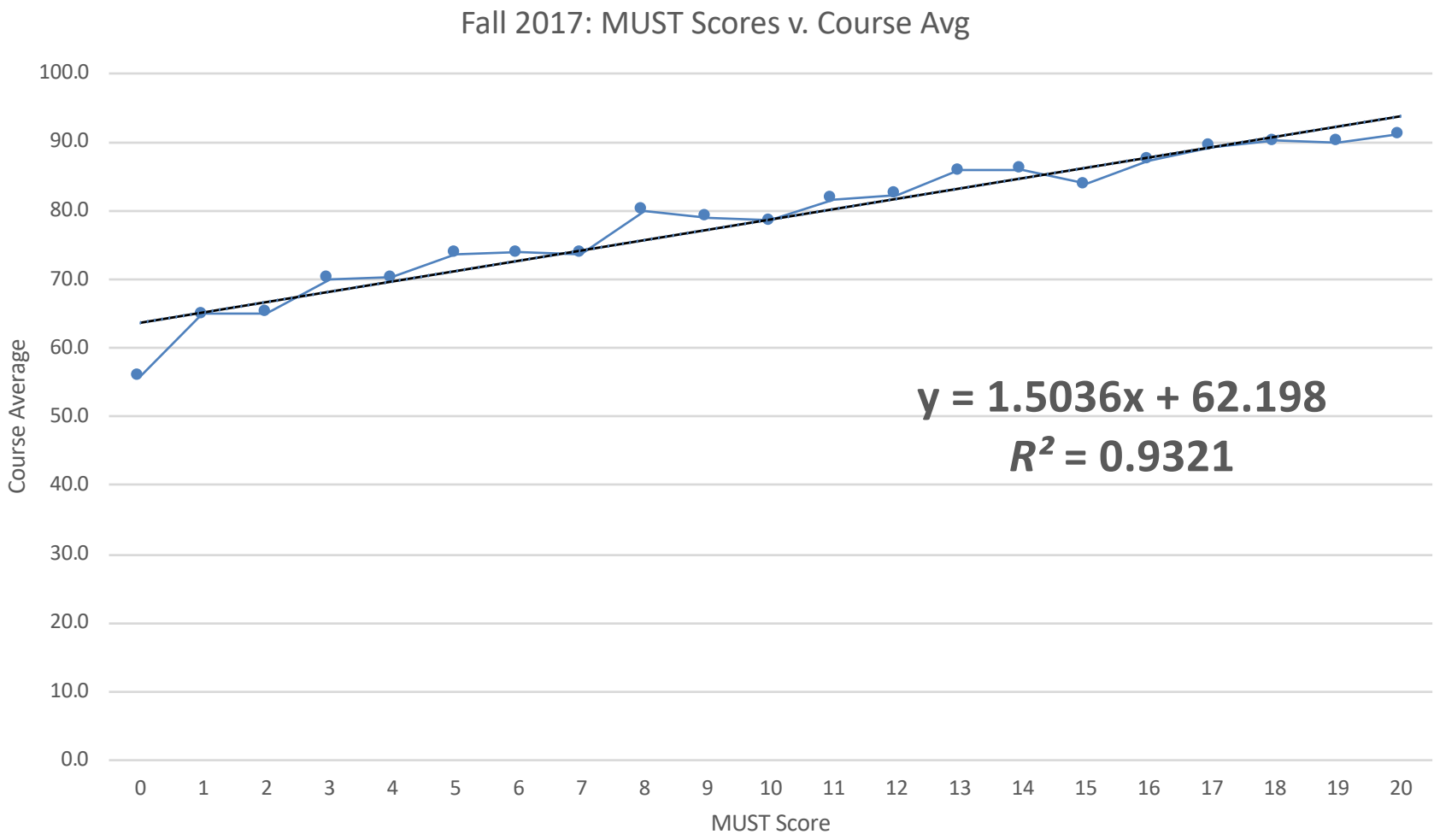
HS Chem	*n* = 1,064	Course Avg (*SD*)	MUST (*SD*)	DAT (*SD*)	PreCal +
AP/IB	240	84.6 (*11.3*)	12.2 (*4.6*)	16.7 (*3.2*)	166/240 = 69.2%
Pre-AP	536	79.8 (*12.9*)	10.4 (*4.8*)	15.7 (*3.4*)	357/536 = 66.6%
Regular	276	76.3 (*13.8*)	8.9 (*4.9*)	14.7 (*3.6*)	138/276 = 50.0%
None	12	71.2 (*13.8*)	6.2 (*3.5*)	13.1 (*5.2*)	6/12 = 50.0%

Mathematics

Grade	Cal I or II *n* (avg %)	PreCal *n* (avg %)	Col Alg *n* (avg %)	Prob/Stat *n* (avg %)	None/Dev *n* (avg %)	No Report *n* (avg %)
A	103 (93.5%)	138 (94.1%)	48 (92.5%)	8 (92.7%)	10 (91.9%)	1 (89.3%)
B	99 (84.6%)	117 (83.7%)	79 (83.5%)	14 (84.6%)	17 (83.7%)	1 (81.6%)
C	51 (73.9%)	90 (73.7%)	81 (73.2%)	17 (73.7%)	17 (74.5%)	1 (73.6%)
D	12 (64.5%)	35 (63.3%)	43 (64.3%)	7 (64.3%)	9 (63.3%)	3 (65.7%)
F	11 (53.5%)	15 (50.5%)	28 (49.9%)	9 (42.0%)	9 (44.1%)	0
Total	276 (83.8%)	395 (82.0%)	279 (75.8%)	55 (72.8%)	62 (73.8%)	6 (65.7%)

Majority of students (276 + 395/1,073 = 62.5%) currently are enrolled in pre-cal or higher (groups A and B) and have a B average.

Fall 2017 MUST vs. Course Average



Most-missed Example Problems

(< 30% correct)

- Division with exponential notation:

$$\frac{9.0\times10^{-18}}{2.0\times10^{-5}} \qquad \frac{10^{5}\times10^{23}}{10^{-1}\times10^{-6}}$$

- Logs: Determine the base-10 log of: 1000 = _____ and 0.001 = _____

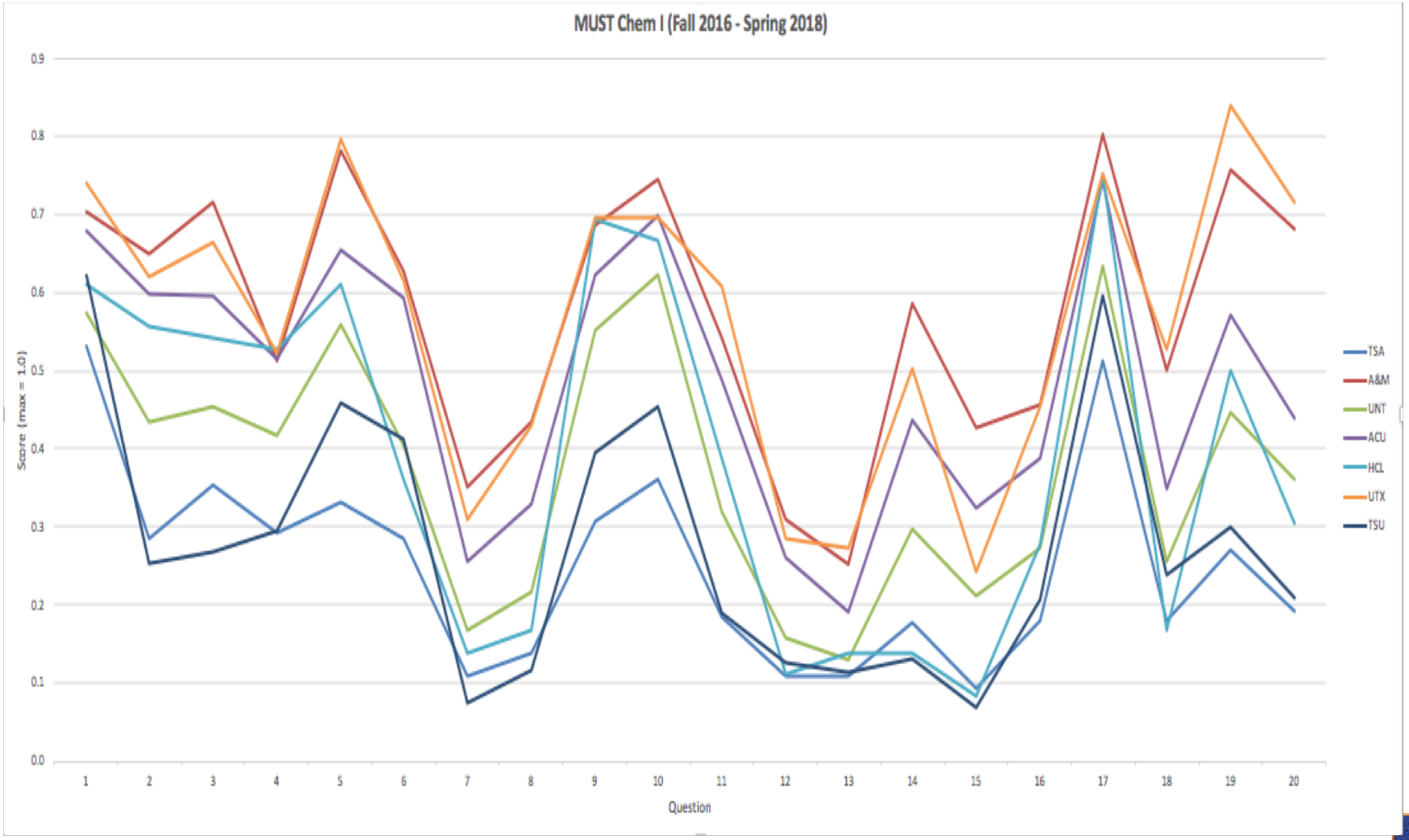
- Power of 10 square root: $\sqrt{64\times10^{-12}}$

- *Division by 0: If A = B, evaluate $\frac{A}{A-B}$

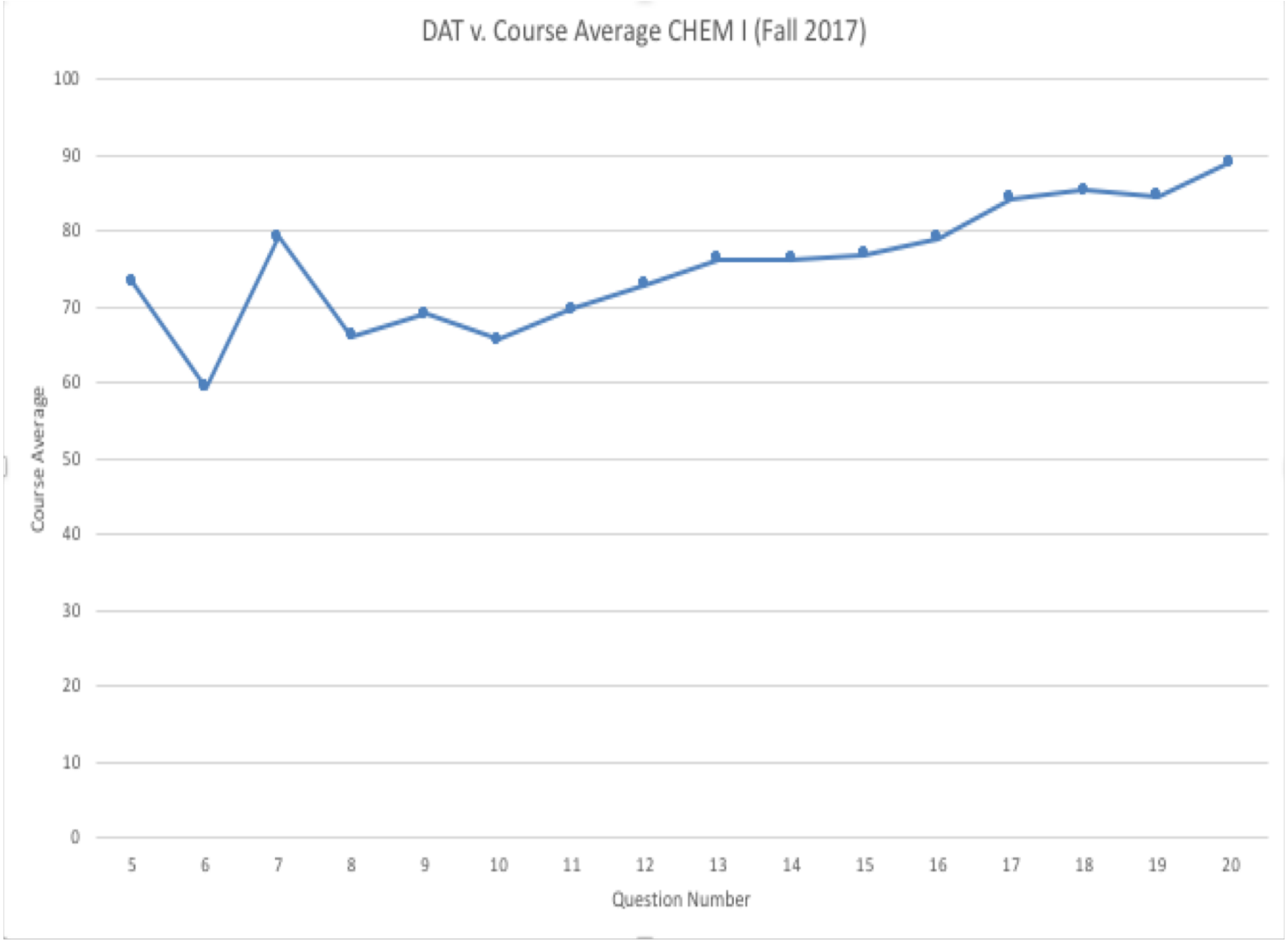
None of 20 questions > 70% correct!

*New question for fall 2017

MUST (by institution)

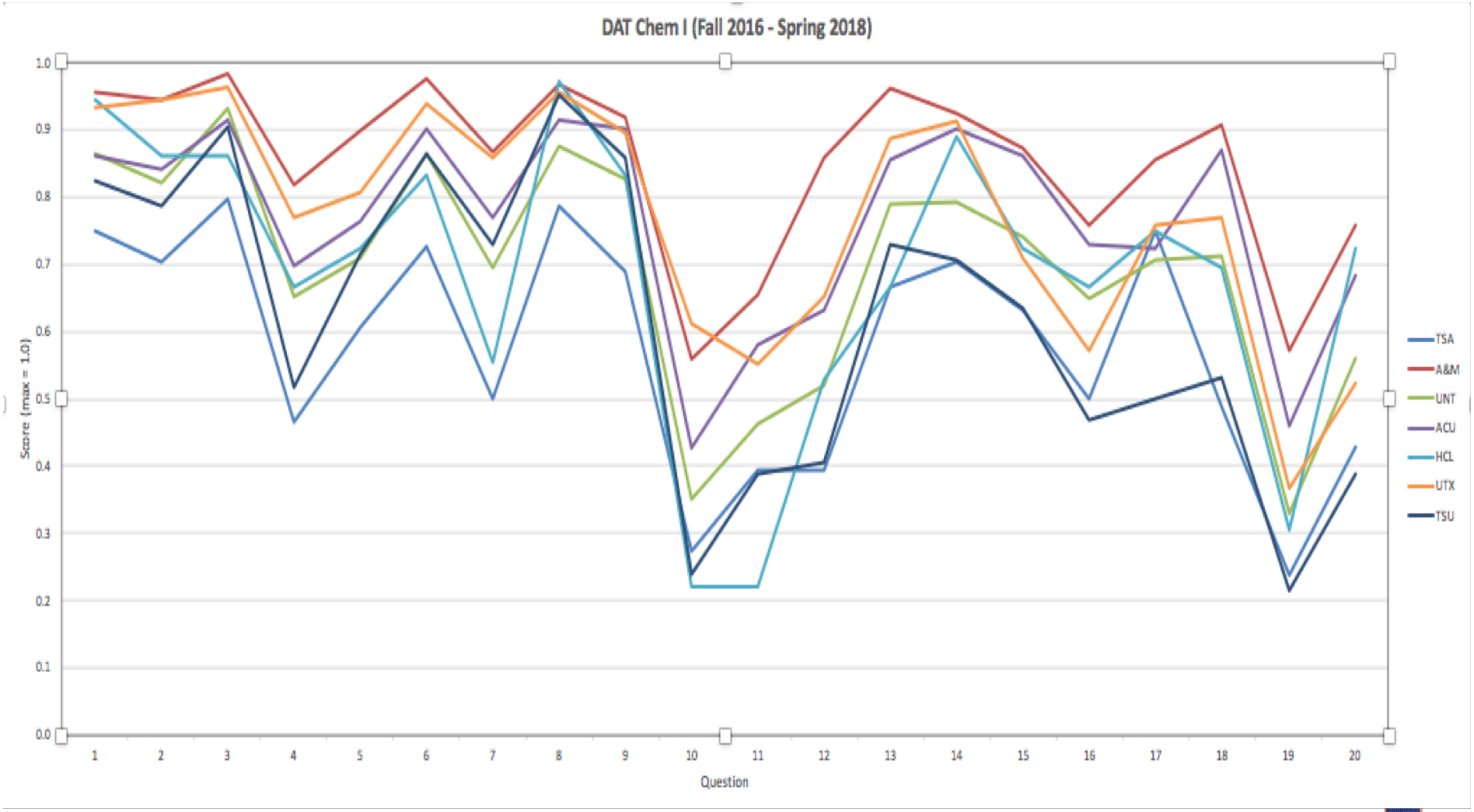


DAT: Algebra Skills

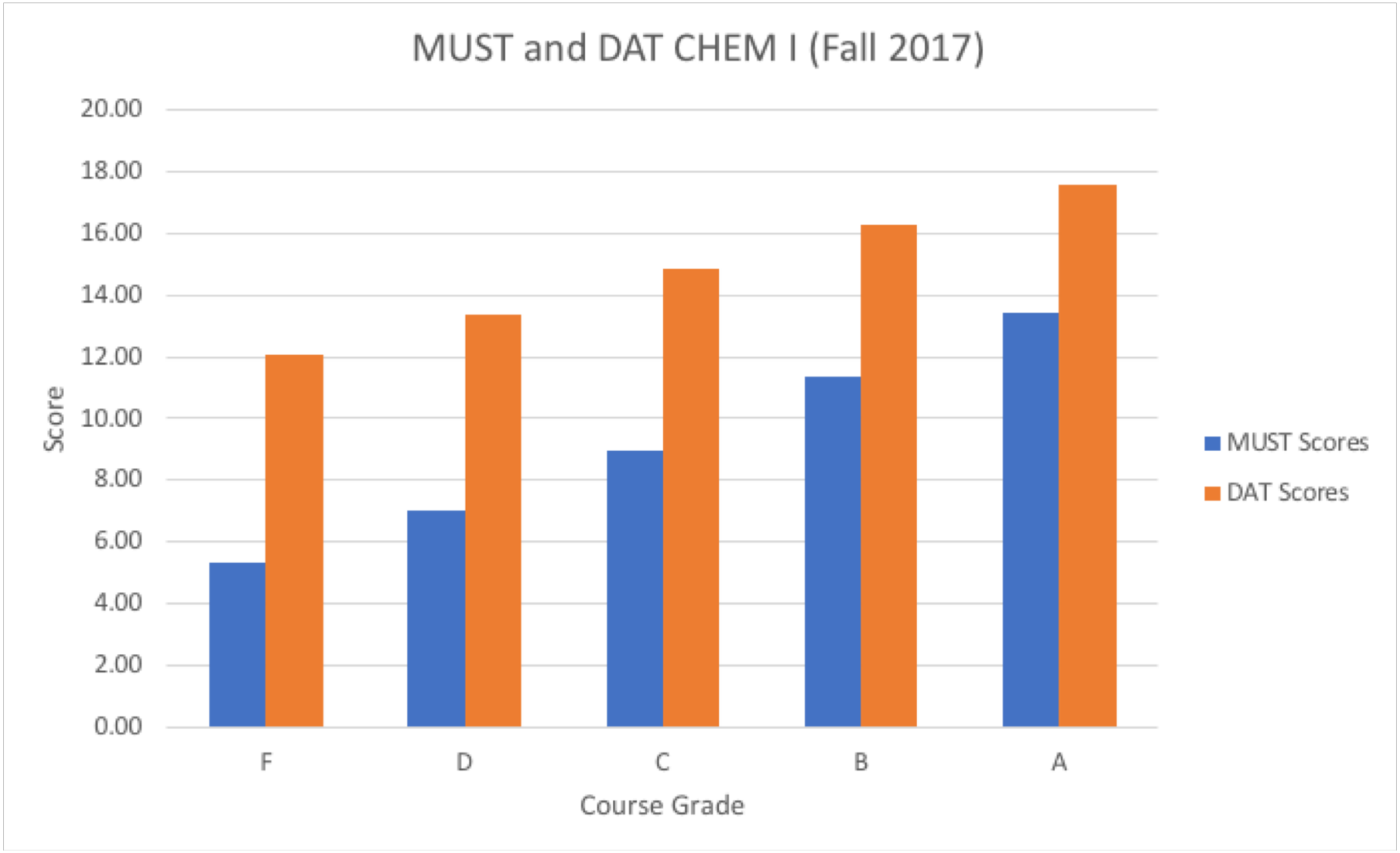


Slope: $m = 1.39$

DAT (by institution)

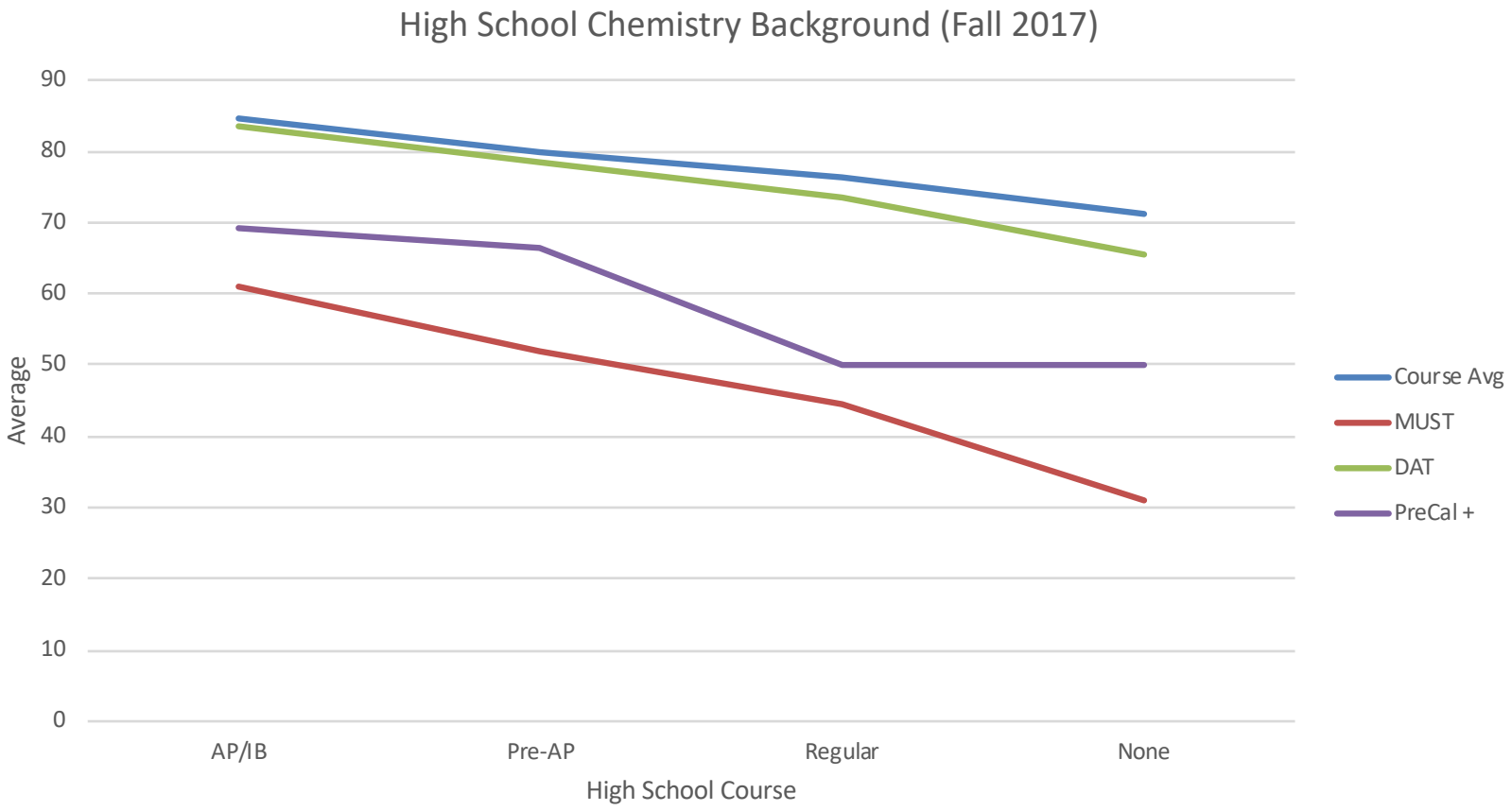


Letter Grades



Identify the potential D/F students at the beginning of semester (or before) and provide them with the HIPs needed to improve their math-sense!

Prior Knowledge



Correlations & Effect Sizes

Course average (*SD*) = 76.75 (*15.56*)

Correlation (*r*): MUST:DAT = 0.700

n = 3.266	Max = 20 points	Correlation to Avg	R^2
MUST	7.75 = 38.75%	0.398	0.158
DAT	14.71 = 73.55%	0.324	0.105

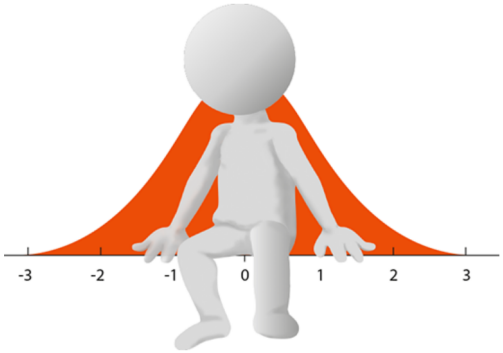
Effect Size DAT : Course Avg = .206 [small]
indicating 50% chance of predicting average from DAT (algebra skills)

Effect Size MUST : Course Avg = 2.22 [huge]
indicating that there is a **80% chance** (or greater) of predicting course average from MUST (arithmetic skills)

Predictability of MUST Ranges (Fall 2017)

MUST Range	*n*	Average (*SD*) (*SE*)	*n* with Average < 69.5% (% in MUST range)
Above average (> 12)	392	87.05 (8.85) (0.45)	12 (3.06%)
Average (8-12)	347	80.42 (10.90) (0.59)	45 (12.97%)
Below average (< 8)	334	70.85 (13.71) (0.75)	123 (36.82%)
Total	**1073**	**79.86 (13.02) (0.40)**	**180 (16.78%)**

Average Student Profile



Nonacademic

- Parents and grandparents have some college
- Does not work

College

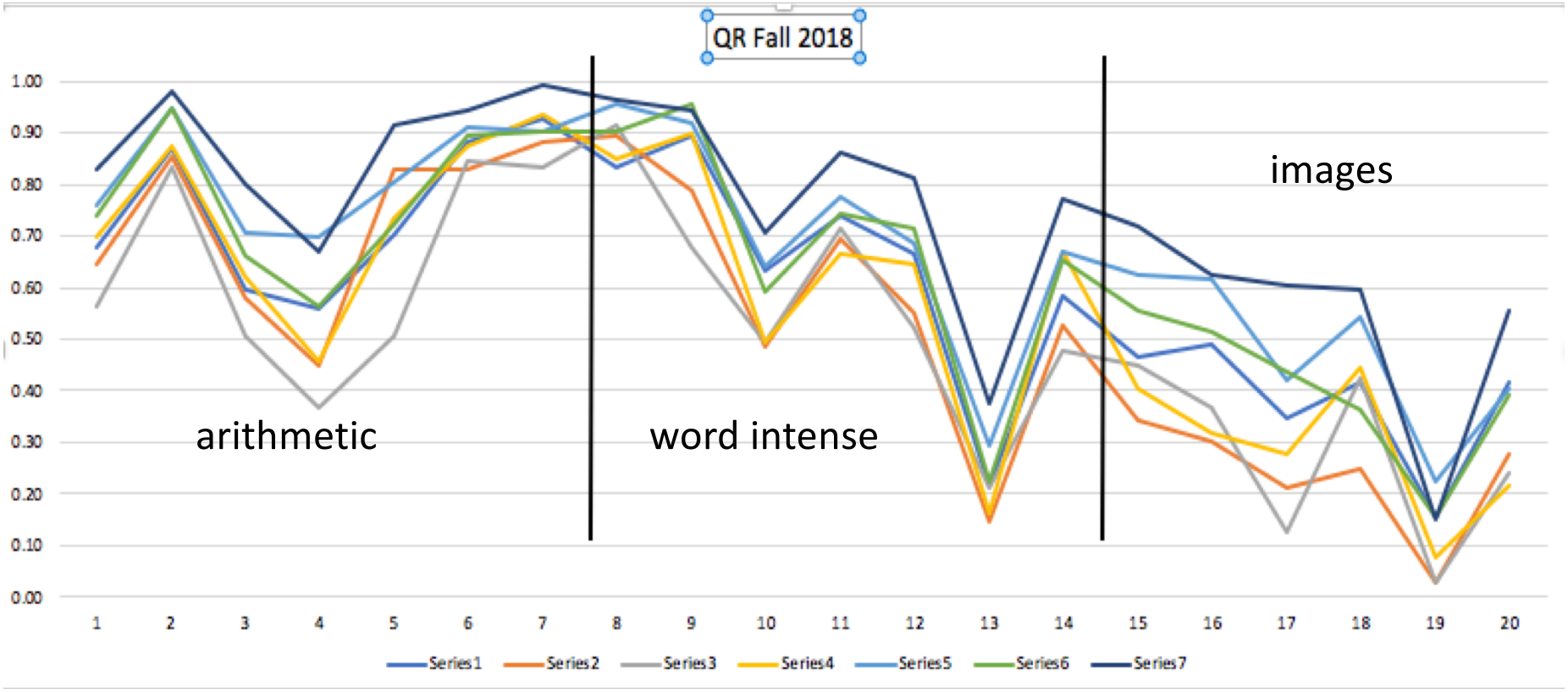
- First-time in course (Avg = 76%)
- STEM major
- Co-enrolled in Pre-Calc or higher
- Plans to take Chem II

Preparation

- Graduated from TX High School
- Took Pre-AP Chemistry

AY 3: QR Introduction

Quantitative Reasoning (Fall 2018)



N = 643; correlation between MUST and QR = 0.658 (a little lower than with the DAT, *r* = 0.700); mean on MUST = 6.69; mean on QR = 12.09

Most Missed QR Arithmetic

0.8% means:

a. 8 out of 100 b. 0.8 c. 8.0 d. 0.08 e. $\frac{0.8}{100}$

Most Missed QR Word Problems

Let $U_A = \frac{r}{1-U_B}$. Solve this equation for U_B in terms of U_A and r.

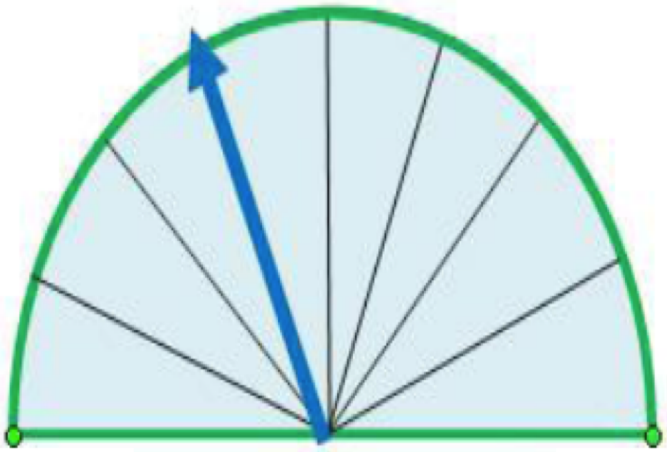
a. $\frac{r-U_A}{r}$ b. $\frac{r-U_A}{U_A}$ c. $\frac{1-r}{U_A}$ d. $\frac{U_A-r}{r}$ e. $\frac{U_A-r}{U_A}$

In a certain company there are 3 times as many men working as women. What is the fraction of employees that are female?

a. $\frac{1}{3}$ b. $\frac{3}{10}$ c. $\frac{2}{3}$ d. $\frac{3}{4}$ e. $\frac{1}{4}$

Near Most Missed QR with Image

The attached gauge shows the power output of a small motor up to one-half horsepower (hp). Express the power output shown by the gauge in horsepower (hp), simplifying any fractions. Assume that the sections are evenly spaced.



0 hp ½ hp

a. 2/9 b. 3/4 c. 3/8 d. 3/16 e. 4/3

Most Missed QR with Image

19. Choose the answer that best describes a comparison between the number of students from the Midwest and the number of International students.

a. The number of students from the Midwest is 2% more than the number of International students.
b. Twice as many students came from the Midwest as from International locations.
c. There are 25 more students from the Midwest than from International locations.
d. The number of International students is 25% more than the number from the Midwest.
e. The number of students from the Midwest is 50% more than the number of International students.

MUST vs QR: Institution

	n	MUST	QR
Small, HSI	71	2.23	9.75
Middle, Pub	76	5.26	10.20
Large, HSI	79	5.61	10.97
Small, HSI	84	6.36	11.68
Large, Pub	115	6.96	12.27
Large, Pub	112	8.08	13.13
Small, Private	106	10.00	14.87
Total	**643**	**6.69**	**12.09**

*MUST and QR scores are in alignment.

MUST vs QR: Gender

	n	MUST*	QR*
Female	308	4.96 (3.78)	10.68 (3.10)
Male	221	7.56 (4.92)	12.73 (3.40)
Total	**531**	**6.05**	**11.54**

MUST and QR scores are in alignment.

*Males statistically outperformed females on MUST and QR.

MUST vs QR: Ethnicity

	n	MUST*	QR*
Non-Hispanic	328 (62.4%)	6.81 (4.57)	12.07 (3.40)
Hispanic	198 (38.6%)	4.67 (3.82)	10.66 (3.12)
Total	**526**	**6.01**	**11.54**

MUST and QR scores are in alignment.
Non-Hispanics statistically outperformed Hispanics on MUST and QR.

MUST vs QR: Race

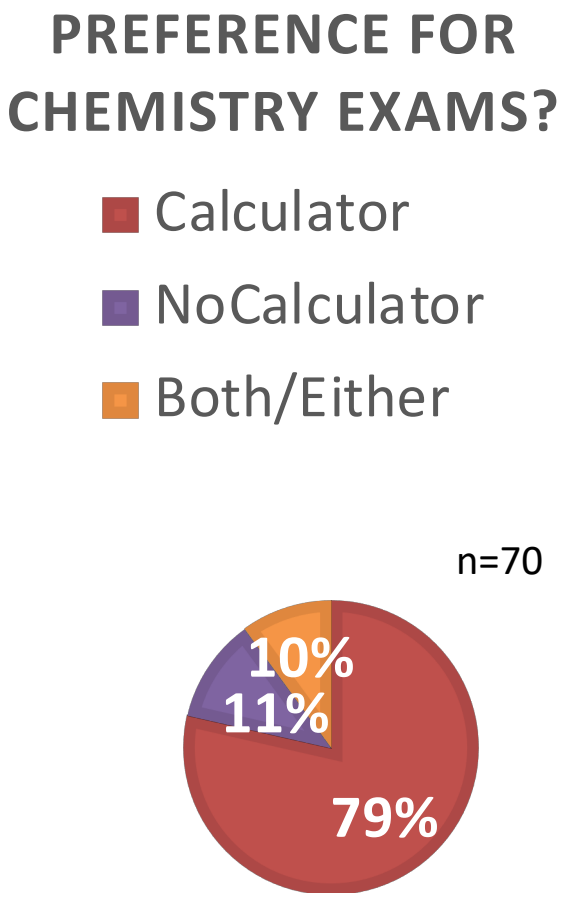
	n (%)	MUST	QR
Asian/PI	49 (9.4%)	7.82 (4.75)	12.06 (3.45)
Mixed	9 (1.7%)	6.33 (4.47)	*11.22 (3.31)
White	313 (60.3%)	6.05 (4.41)	*11.86 (3.24)
Black	78 (15.0%)	5.99 (4.28)	11.00 (3.43)
Native Am/Alaskan	10 (1.9%)	5.70 (4.17)	10.90 (4.41)
Other	60 (11.6%)	4.58 (3.95)	10.42 (3.40)
Total	**519**	**6.03**	**11.55**

*MUST and QR scores are almost in alignment.

HIGH IMPACT PRACTICES (HIP)

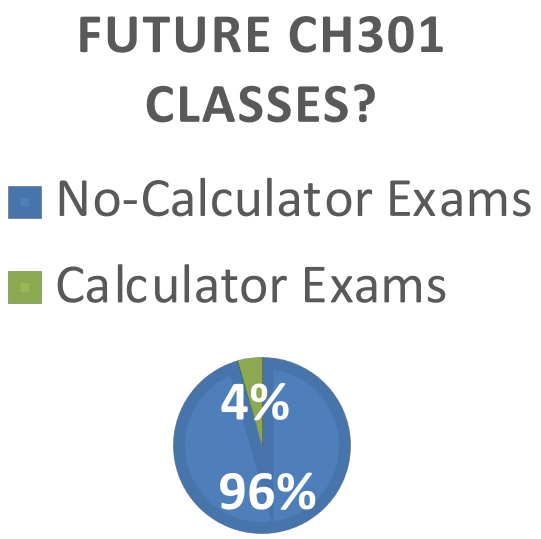
Your Preference?

- No Calculator:
  - "I prefer the chemistry exams ***without*** a calculator... With a calculator, you could take a ***long time*** because you can use the answer and try ***to work backwards***. Without a calculator, you either know it or you don't.
- Calculator:
  - "I prefer exams with a calculator because I know the process however sometimes ***I get nervous*** or anxious during exams which hinders my mathematical capabilities and ***the calculator makes sure*** that doesn't get the better of me and that ***my grade remains intact***."



Recommend to Future Students?

- No Calculator:
  - "Honestly, I think not using a calculator has ***better prepared*** me for CH302."
- Calculator:
  - "The ***reason I failed*** my first two exams in CH301 was because I struggled greatly with ***estimating***. I don't feel like that's fair because I knew the chemistry and this is a chemistry course."



n=69

Next Steps

- Determine the degree to which QR skills relate to success in general chemistry
- Implement HIPs
  - Re-awaken numeracy skills
  - Support QR skill development
- Spread the word
  - Numeracy skills are declining in college students

Summary

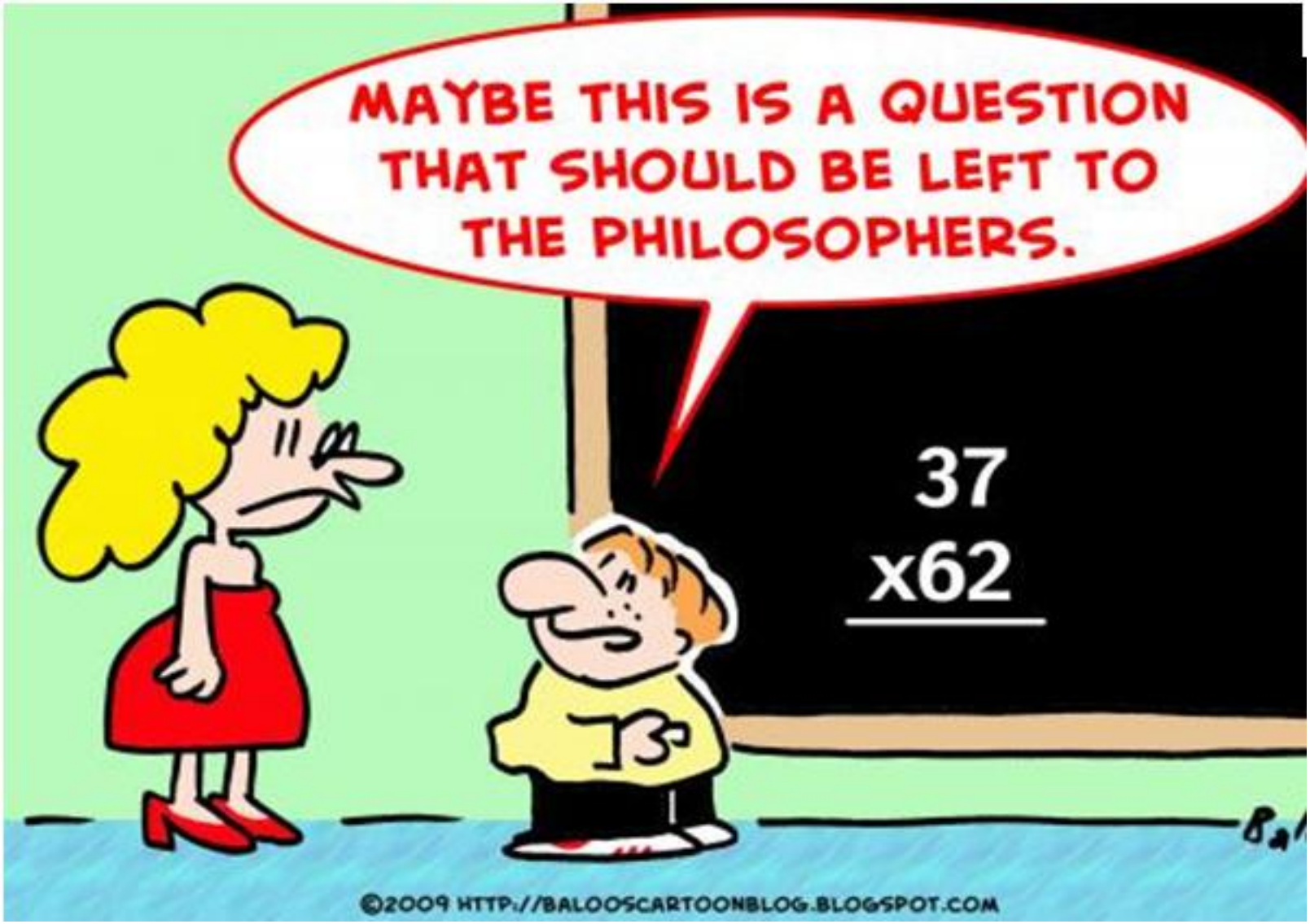
- Numeracy skills are “low-hanging fruit”
  - MUST identifies at-risk students taking chemistry
  - Number sense is linked to chemistry course success
- Quantitative Reasoning warrants further study
  - Numeracy skills may be limited by reasoning skills
  - Chemistry success may improve as both QR and numeracy skills improve

Acknowledgments

Many thanks to the Networking for Science Advancement (NSA) Team for contributing to this statewide project!

Also, thanks are extended to Eric Gaze for getting the NSA Team started on QL/QR research line and sharing his problems from QLRA with us, and to Peter Brown for allowing us to select problems from his “Number Sense” research collection of problems that can be solved without e-devices!

Questions?


MAYBE THIS IS A QUESTION THAT SHOULD BE LEFT TO THE PHILOSOPHERS.
37
x62
©2009 HTTP://BALOOSCARTOONBLOG.BLOGSPOT.COM

Diagnostic Instruments

- Math-Up Skills Test (MUST): arithmetic skills
  - Hartman, JA. R.; Nelson, E. A. *Automaticity in Computation and Student Success in Introductory Physical Science Courses.* Cornell University Library. arXiv:1608.05006v2 [physics.ed-ph]
    - Quiz: http://bit.ly/1HyamPc **(Named: MUST)**
  - Authors
    - Hartman (U.S. Naval Academy)
    - Nelson, Chemistry instructor (multi-institutions)
  - Highly reliable (*KR-20* = 0.863)
- Diagnostic Algebra Test (DAT)
  - Cooper, C. I., Pearson, P. T. (2012). A Genetically Optimized Predictive System for Success in General Chemistry Using a Diagnostic Algebra Test. *Journal of Science Education and Technology*, 21 (1), 197-205.